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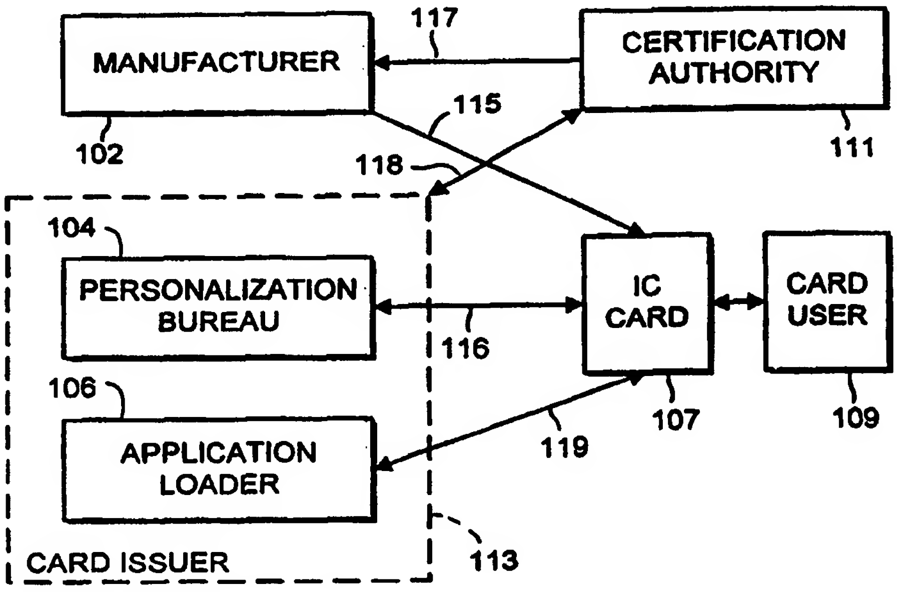

(57) Abstract

A secure multiple application card system and process are provided having secure loading and deleting capability by use of a Certification Authority and Personalization Bureau. The certification authority maintains the security of the system by requiring IC cards to be injected with its public key and a card identifier for uniquely identifying each card, by providing a personalization data block for each card, and by signing with its private key all applications to be loaded or deleted from the IC card.

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SECURE MULTIPLE APPLICATION CARD SYSTEM AND PROCESS

BACKGROUND OF INVENTION

Integrated circuit ("IC") cards are becoming increasingly used for many different purposes in the world today. An IC card (also called a smart card) typically is the size of a conventional credit card which contains a computer chip including a microprocessor, read-only-memory (ROM), electrically erasable programmable read-only-memory (EEPROM), an Input/Output (I/O) mechanism and other circuitry to support the microprocessor in its operations. An IC card may contain a single application or may contain multiple independent applications in its memory. MULTOS™ is a multiple application operating system which runs on IC cards, among other platforms, and allows multiple applications to be executed on the card itself. This allows a card user to run many programs stored in the card (for example, credit/debit, electronic money/purse and/or loyalty applications) irrespective of the type of terminal (i.e., ATM, telephone and/or POS) in which the card is inserted for use.

A conventional single application IC card, such as a telephone card or an electronic cash card, is loaded with a single application at its personalization stage. That application, however, cannot be modified or changed after the card is issued even if the modification is desired by the card user or card issuer. Moreover, if a card user wanted a variety of application functions to be performed by IC cards issued to him or her, such as both an electronic purse and a credit/debit function, the card user would be required to carry multiple physical cards on his or her person, which would be quite cumbersome and inconvenient. If an application developer or card user desired two different applications to interact or exchange data with each other, such as a purse application interacting with a frequent flyer loyalty application, the card user would be forced to swap multiple cards in and out of the card-receiving terminal, making the transaction difficult, lengthy and inconvenient.

Therefore, it is beneficial to store multiple applications on the same IC card. For example, a card user may have both a purse application and a credit/debit application on the same card so that the user could select which type of payment (by electronic cash or credit card) to use to make a purchase. Multiple applications could be provided to an IC card if sufficient memory exists and an operating system capable of supporting multiple applications is present on the card. Although multiple applications could be pre-selected and placed in the memory of the card during its production stage, it would also be beneficial to have the ability to load and delete applications for the card post-production as needed.

The increased flexibility and power of storing multiple applications on a single card create new technical challenges to be overcome concerning the integrity and security of the information (including application code and associated data) exchanged between the individual card and the application provider as well as within the entire system when loading and deleting applications. It would be beneficial to have the capability in the IC card system to exchange data among cards, card issuers, system operators and application providers securely and to load and delete applications securely at any time from either a terminal or remotely over a telephone line, internet or intranet connection or other data conduit. Because these data transmission lines are not typically secure lines, a number of security and entity-authentication techniques must be implemented to make sure that applications being sent over the transmission lines are only loaded on the intended cards.

As mentioned, it is important -- particularly where there is a continuing wide availability of new applications to the cardholder -- that the system has the capability of adding applications onto the IC card subsequent to issuance. This is necessary to protect the longevity of the IC cards; otherwise, once an application becomes outdated, the card would be useless. In this regard, to protect against the improper or undesired loading of applications onto IC cards, it would be beneficial for the IC card system to have the capability of controlling the loading process and restricting, when necessary or desirable, the use of certain applications to a limited group or number of cards such that the applications are "selectively available" to the IC-cards in the system. This "selective capability" would allow the loading and deleting of applications at, for example, a desired point in time in the card's life cycle. It would also allow the loading of an application only to those cards chosen to receive the selected application.

Accordingly, it is an object of embodiments of this invention to provide these important features and specifically an IC-card system having improved security that allows for selective availability of smart card applications which may be loaded onto IC cards.

SUMMARY OF THE INVENTION

These and other objectives are achieved by embodiments in accordance with the present invention which provide an IC card system comprising at least one integrated circuit card and having a certification authority and a personalization bureau. The certification authority ("CA") maintains encryption and decryption keys for the entire system and provides the card manufacturer with security data to be placed on the card at manufacture. Thus, there is advantageously provided a secure multiple application card system.

Specifically, in a preferred embodiment, an IC card is injected at manufacture with the public key of the CA and a card identifier for uniquely identifying each of the cards. Subsequent to manufacturer, the cards are preferably provided to a personalization bureau ("PB") which could be a card issuer, for enabling the cards. The PB obtains from the cards the identifiers and forwards a list of card identifiers to the CA.

The CA in turn creates a personalization data block for each card identifier, and each data block preferably includes card personalization data and an individual key set. The data block is encrypted and forwarded back to the PB. By using the card identifier, the PB then matches the cards with the encrypted data blocks and separately loads each data block onto the matched card, and preferably sets an enablement bit indicating that the card has been enabled and is ready for application loading.

The application loading process is preferably performed at the PB. At first, the system checks to see whether the card to be loaded is qualified (as defined below) to accept the loading of a specific application. The application loader via a terminal will be advised if the card is qualified and, if so, a check will be done using the CA's public key to determine whether the application to be loaded has been signed by the CA's secret key indicating that the application to be loaded has been allowed by the CA.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects, features and advantages of embodiments in accordance with the invention will become apparent from the following detailed description taken by way of example only and in conjunction with the accompanying figures showing illustrative embodiments of the invention, in which

Fig. 1 is block diagram illustrating the three stages in the life of a multi-application IC card in a secure system;

Fig. 2 is a block diagram illustrating the steps of the card manufacture process;

Fig. 3 is a flow diagram illustrating the steps involved in enabling each of the IC cards in the secure system;

Fig. 4 is a block diagram of an IC card chip which can be used in accordance with the invention;

Fig. 5 is a block diagram illustrating the data stored on the IC card as indicated in block 307 of Fig. 3;

Fig. 5A is a schematic of the data structures residing in an IC card and representing personalization data;

Fig. 6 is a flowchart illustrating the steps of loading an application onto an IC card in the secure system;

Fig. 7 is a flow chart illustrating the checking steps as indicated in block 601 of Fig. 6;

Fig. 8 is a flowchart illustrating the steps undertaken in determining if loading of an application may proceed;

Fig. 9 is a block diagram showing the components of the system architecture for the enablement process of an IC card in a secure multi-application IC card system; and

Fig. 10 is a system diagram of entities involved with the use of the IC card once it has been personalized.

Throughout the figures, the same reference numerals and characters, unless otherwise stated, are used to denote like features, elements, components or portions of the illustrated embodiments. Moreover, while the subject invention will now be described in detail with reference to the figures, it is done so in connection with the illustrative embodiments. It is intended that changes and modifications can be made to the described embodiments without departing from the true scope and spirit of the subject invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

An embodiment in accordance with the present invention provides an IC card system and process which allow the flexibility to load and delete selected applications over the lifetime of a multi-application IC card in response to the needs or desires of the card user, card issuers and/or application developers. A card user who has such a card can selectively load and delete applications as desired if allowed by the card issuer in conjunction with the system operator or Certification Authority ("CA") which controls the loading and deleting process by certifying the transfer of information relating to the process.

By allowing applications to be selectively loaded and deleted from the card, a card issuer can extend additional functionality to an individual IC card without having to issue new cards. Moreover, application developers can replace old applications with new enhanced versions, and applications residing on the same card using a common multiple application operating system may interact and exchange data in a safe and secure manner. For example, a frequent flyer loyalty program may automatically credit one frequent flyer mile to a card user's internal account for every dollar spent with the Mondex purse or with a credit/debit application. By allowing the ability to selectively load and delete applications, the card user, subject to the requirements of the card issuer, also has the option of changing loyalty programs as desired.

A card issuer or application developer may intend that a particular application be loaded on only one card for a particular card user in a card system. A regional bank may desire to have a proprietary application reside only on the cards which the bank issues. Embodiments of the present invention would allow for this selective loading and specifically allow for the prevention of loading proprietary applications onto unauthorized cards issued by others.

To achieve these desired objectives, an embodiment in accordance with the present invention gives each card a specific identity by storing "card personalization data" on the card. Moreover, each application to be loaded or deleted on one or more cards in the system is assigned "application permissions data" which specify the cards upon which the applications may be loaded.

The type of personalized data can vary depending upon the needs and requirements of the card system. In the preferred embodiment, described in greater detail below, the personalization data include unique card identification designation data, the card issuer, the product class or type (which is defined by the card issuer) and the date of personalization. However, not all of these data elements are required to be used and additional elements could also be included.

The application permissions data associated with an application, also described in greater detail below, can be a single value in an identity field or could include multiple values in the identity field. For example, the application permissions data in the card issuer field could represent both product class A and product class B from a certain Bank X, indicating that the application could be loaded onto cards designated as product classes A and B issued by Bank X (as indicated in the card product ID field of the card's personalization data).

In addition, a "global value" could be stored in the issuer field (or other field) of the application permissions data indicating that all IC cards in the system regardless of who issued the card would match this permissions field. In this case, for example, a data value of zero stored in the application permissions card-issuer field will match all of the cards' personalization card-issuer fields.

Figure 1 shows the three steps involved in providing an operational multi-application IC card in a secure system. The first step is the card manufacturing step 101. The second step is the personalization step 103 where card personalization data (also called entity authentication data) is loaded onto the card. The third step is the application loading step 105 which checks to see if a card is qualified to receive an application, i.e., when the personalization data is checked against the application permissions data associated with the application to be loaded. Each of these three steps is described in detail below.

Card Manufacture

Figure 2 shows the steps necessary in manufacturing an IC card in a secure system. Step 201 manufactures the physical IC card by creating the integrated circuit on silicon and placing it on the card. The integrated circuit chip will include RAM, ROM and EEPROM memories. When the card is first manufactured, a global public key of the system operator (in this case called the Certification Authority (CA)) is stored on each card in ROM in step 203. This will allow the card to authenticate that the source of any message to it is from the CA since the public key on the card will be matched to the CA's secret key.

More specifically, this public key stored on the card will allow the individual card to verify data signed with the CA's private key. The public key of the CA, which is stored on the card, is used only for determining if the data sent to the card was signed with the proper CA private key. This allows the card to verify the source of any message coming from the CA.

Step 205 inserts a card enablement key in a secure portion of EEPROM in the card to facilitate card specific confidentiality during enablement, and step 207 inserts a card identifier in EEPROM of the card. The identifier, which can be accessed by any terminal, will allow the system to determine the identity of the card in later processes. The identifier is freely available and will not be used to authenticate messages.

Step 209 stores the operating system code in ROM on the card including any primitives which are called or supported by the operating system. The primitives are written in native language code (e.g., assembly language) and are stored in ROM. The primitives are subroutines which may be called by the operating system or by applications residing on the card such as mathematic functions (multiply or divide), data retrieval, data manipulation or cryptographic algorithms. The primitives can be executed very quickly because they are written in the native language of the processor. After the IC cards are manufactured, they are sent to a personalization bureau ("PB") to enable and personalize the card by storing card personalization data in the memory of the card. The terms enablement and personalization are used interchangeably herein to indicate the preparatory steps taken to allow the card to be loaded securely with an application. The individual cards are preferably manufactured in batches and are sent to a personalization bureau in a group for processing.

Card Enablement/Personalization

Figure 3 shows the steps of the card enablement process when the card arrives at a personalization bureau. The personalization bureau may be the card issuer (e.g., a bank or other financial institution) or may be a third party that performs the service for the card issuer. The personalization bureau configures the card to a specific user or user class.

Figure 3 specifically shows the steps taken to enable and personalize each IC card which will work within the system. The cards can be placed in a terminal which communicates with IC cards and which reads the card identifier data (previously placed on the card during the manufacturing process -- see step 207). This card identification data is read from the card in step 301. The terminal will effectively send a "get identification data" command to the card and the card will return the identification data to the terminal.

The PB typically processes a group of cards at the same time, and will first compile a list of IC card identification data for the group of cards it is personalizing. The PB then sends electronically (or otherwise) this list of identification data to the Certification Authority ("CA") which creates a personalization (or enablement) data block for each card identifier. The data block includes the card personalization data organized in a number of identity fields and an individual key set for the card, discussed below. These data blocks are then encrypted and sent to the PB in step 302. By using the card identification data, the

PB then matches the cards with the encrypted data blocks and separately loads each data block onto the matched card. To insure that the CA controls the identity of the card and the integrity of the system, the PB never obtains knowledge of the content of the data blocks transferred. Some aspects of the personalization are requested by the card issuer to the CA in order to affect their preferred management of the cards they issue. The following additional steps are performed.

Step 303 first checks to see if an enablement bit stored in EEPROM of the card has been already set. If it already has been set, the card has already been configured and personalized and the enablement process will end as shown in step 304. A card cannot be enabled and personalized twice. If the bit has not been set, then the process continues with step 305.

In step 305, the individualized card key set for the card being enabled (which key set is generated at the CA) is stored on the card. The keys can be used later in off-card verification (i.e., to verify that the card is an authentic card). This verification is necessary to further authenticate the card as the one for which the application was intended.

Step 307 generates four different MULTOS Security Manager (MSM) characteristic data elements (otherwise referred to herein as personalization data) for the card at the CA which are used for securely and correctly loading and deleting applications from a particular card. The MSM characteristics also allow for the loading of applications on specific classes of identified cards. (These MSM characteristics are further described in connection with Figure 5.)

Other data can also be stored on the card at this time as needed by the system design such as an address table or further subroutines.

Step 311 sets the enablement bit in EEPROM of the card which indicates that the enablement process has been completed for the particular card. When this bit is set, another enablement process cannot occur on the card. This ensures that only one personalization and enablement process will occur to the card thus inhibiting illegal tampering of the card or altering the card by mistake. In the preferred embodiment, the enablement bit is initially not set when the card is manufactured and is set at the end of the enablement process.

Figure 4 shows an example of a block diagram of an IC card chip which has been manufactured and personalized. The IC card chip is located on an IC card for use. The IC card preferably includes a central processing unit 401, a RAM 403, a EEPROM 405, a ROM 407, a timer 409, control logic 411, an I/O ports 413 and security circuitry 415, which are connected together by a conventional data bus.

Control logic 411 in memory cards provides sufficient sequencing and switching to handle read-write access to the card's memory through the input/output ports. CPU 401 with its control logic can perform calculations, access memory locations, modify memory contents, and manage input/output ports. Some cards have a coprocessor for handling complex computations like cryptographic algorithms. Input/output ports 413 are used under the control of a CPU and control logic alone, for communications between the card and a card acceptance device. Timer 409 (which generates or provides a clock pulse) drives the control logic 411 and CPU 401 through the sequence of steps that accomplish memory access, memory reading or writing, processing, and data communication. A timer may be used to provide application features such as call duration. Security circuitry 415 includes fusible links that connect the input/output lines to internal circuitry as required for testing during manufacture, but which are destroyed ("blown") upon completion of testing to prevent later access. The personalization data to qualify the card is stored in a secured location of EEPROM 405. The comparing of the personalization data to applications permissions data is performed by the CPU 401.

Figure 5 shows the steps of generating and loading the four elements of the card personalization data into the memory of the IC cards, and Fig. 5A shows a schematic of bit maps for each identity field residing in the memory of an IC card containing personalization data in accordance with the present invention. Each data structure for each identity field has its own descriptor code. Step 501 loads the data structure for the identity field "card ID" called "msm_mcd_permissions_mcd_no." This nomenclature stands for MULTOS system manager _ MULTOS card device _ permissions_ MULTOS card device number. Although this number is typically 8 bytes long as shown in Fig. 5A, the data could be any length that indicates a unique number for the card. In the preferred embodiment, 2 bytes are dedicated as a signal indicator, 2 bytes comprise a MULTOS Injection Security Module ID (MISM ID) indicating which security module injected the card with its injected keys when it was manufactured, and 4 bytes comprise an Integrated Circuit Card (ICC) serial number which identifies the individual card produced at the particular MISM.

Step 503 loads the data structure for the identity field "issuer ID" called "msm_mcd_permissions_ mcd_issuer_id." This nomenclature stands for a MULTOS card device issuer identification number. Each card issuer (such as a particular bank, financial institution or other company involved with an application) will be assigned a unique number in the card system. Each IC card in the MULTOS system will contain information regarding the card issuer which personalized the card or is responsible for the card. A card issuer will order a certain number of cards from a manufacturer and perform or have performed the personalization process as described herein. For example, a regional bank may order 5,000 cards to be distributed to its customers. The "mcd_issuer_id" data structure on these cards will indicate which issuer issued the cards. In the preferred embodiment, the data structure is 4 bytes long (as shown in Fig. 5A at 503A) to allow for many different issuers in the system although the length of the data structure can vary with the needs of the card system.

Step 505 loads the data structure for the identity field "product ID" called "msm_mcd_permissions_mcd_ issuer_product_id." This nomenclature stands for MULTOS card device issuer product identification number. Each card issuer may have different classes of products or cards which it may want to differentiate. For example, a bank could issue a regular credit card with one product ID, a gold credit card with another product ID and a platinum card with still another product ID. The card issuer may wish to load certain applications onto only one class of credit cards. A gold credit card user who pays an annual fee may be entitled to a greater variety of applications than a regular credit card user who pays no annual fee. The product ID field identifies the card as a particular class and will later allow the card issuer to check the product ID and only load applications onto cards which match the desired class.

Another way to differentiate products is by application type, such as by categorizing the application as financial, legal, medical and/or recreational, or by assigning particular applications to a group of cards. For example, one card issuer may have different loyalty programs available with different companies to different sets of card users. For example, a bank may have an American Airlines® loyalty program and a British Airways® loyalty program for different regions of the country dependent on where the airlines fly. The product type allows the issuer to fix the product classification of the card during the personalization process. When loading applications onto the card, the product type identification number on each card will be checked to make sure it matches the type of card onto which the issuer desires to load. The product type data structure is preferably an indexing mechanism (unlike the other personalization data structure) of 8 bits (as shown at 505A in Fig. 5A) but could be any length depending upon the needs of the card system. In the illustrated embodiment, the resulting instruction would be to locate the second bit (since the byte's indicated value is 2) in the array to be searched (see discussion of step 809 below).

Step 507 loads the data structure for the identity field data called "msm_mcd_permissions_mcd_ controls_data_ date." This nomenclature stands for the MULTOS card device controls data date or, in other words, the date on which the card was personalized so that, for example, the application loader can load cards dated only after a certain date, load cards before a certain date (e.g., for application updates) or load cards with a particular data date. The information can include the year, month and day of personalization or may include less information, if desired. The data_date data structure is preferably 1 byte in length (see 507A in Fig. 5A) although it could be any length depending upon the needs of the particular card system used.

Once all of the personalization data structures are loaded and stored in the card, the card has been identified by issuer, product class, date and identification number (and other data fields, if desired), and the card cannot change its identity; these fields cannot be changed in the memory of the card. If a card user wants to change the product_id stored in the card to gain access to different applications available to another product type, a new card will have to be issued to the user containing the correct personalization data. This system is consistent with a gold card member receiving a new card when the classification is changed to platinum.

After the card has been enabled and personalized by storing its individual card key set, MSM personalization characteristics and enablement bit as described in Fig. 3, the card is ready to have applications loaded into its memory.

Loading Applications

The application loading process contains a number of security and card configuration checks to ensure the secure and proper loading of an application onto the intended IC card. The application loading process is preferably performed at the personalization bureau so that the card will contain one or more applications when the card is issued. The card may contain certain common applications which will be present on every card the issuer sends out, such as an electronic purse application or a credit/debit application. Alternatively, the personalization bureau could send the enabled cards to a third party for the process of loading applications. The multiple application operating system stored in the ROM of each card and the card MSM personalization data is designed to allow future loading and deleting of applications after the card has been issued depending upon the desires of the particular card user and the responsible card issuer. Thus, an older version of an application stored on the IC card could be replaced with a new version of the application. An additional loyalty application could also be added to the card after it has been initially sent to the card user because the application is newly available or the user desires to use the new application. These loading and deleting functions for applications can be performed directly by a terminal or may be performed over telephone lines, data lines, a network such as the Internet or any other way of transmitting data between two entities. In the present IC card system, the process of transmitting the application program and data ensures that only IC cards containing the proper personalization data and which fit on application permissions profile will be qualified and receive the corresponding application program and data.

Figure 6 shows the preferred steps performed in loading an application onto an IC card in the MULTOS IC card system. For this example, the personalization bureau is loading an application from a terminal which enabled the same card. Step 601 performs an "open command" initiated by the terminal which previews the card to make sure the card is qualified to accept the loading of a specific application. The open command provides the card with the application's permissions data, the application's size, and instructs the card to determine (1) if the enablement bit is set indicating the card has been personalized; (2) whether the application code and associated data will fit in the existing memory space on the card; and (3) whether the personalization data assigned to the application to be loaded allows for the loading of the application onto the particular card at issue. The open command could also make additional checks as required by the card system. These checking steps during the open command execution will be described in detail in conjunction with Figure 7.

After the open command has been executed, the application loader via the terminal will be advised if the card contains the proper identification personalization data and if enough room exists in the memory of the card for the application code and related data. If there is insufficient memory, then a negative response is returned by the card and the process is abended (abnormally ended). If the identification personalization data does not match the applications permissions data, a warning response is given in step 603, but the process continues to the load and create steps. Alternatively, if there is no match, the process may automatically be abended. If a positive response is returned by the card to the terminal in step 605, the application loader preferably proceeds to next steps. The open command allows the application to preview the card before starting any transfer of the code and data.

Step 607 then loads the application code and data onto the IC card into EEPROM. The actual loading occurs in conjunction with create step 609 which completes the loading process and enables the application to execute on the IC card after it is loaded. The combination of the open, load and create commands are sent by the terminal, or another application provider source, to the IC card to perform the application loading process. The operating system in the IC cards is programmed to perform a specific set of instructions with respect to each of these commands so that the IC card will communicate with and properly carry out the instructions from the terminal.

Step 609 performs the create command which at least: (1) checks if an application load certificate is signed (encrypted) by the CA and therefore authenticates the application as a proper application for the system; and (2) checks the card personalization data stored on the card against the permissions profile for the application to be loaded to qualify the card for loading. It may do other checks as required. If one of the checks fails, then a failure response 610 is given and the process aborts. The application after it has passed these checks will be loaded into the memory of the card.

Figure 7 shows the various steps of the open step 601 of Fig. 6 in more detail. Step 701 determines if the enablement (i.e., control) bit is set. This bit is set when the card has completed its personalization process and has been assigned its personalization data. An application can be loaded on an IC card in the card system only if the card contains the personalization data. If the enablement bit is not set, the card has not been personalized and therefore the card returns a negative response 703 to the terminal. If the enablement bit is set, then the card has been enabled and the test conditions continue with step 711.

Step 711 checks if there is sufficient space in the memory on the card to store the application code and its associated data. Applications will typically have associated data related to their functions. This data will be used and manipulated when the application is run. Storage space in the memory of an IC card is a continuing concern due to the relatively large physical space required for EEPROM and how it fits in the integrated circuit which is desired to be small enough to fit on a credit card sized card. An example of the size of a preset EEPROM on an IC card is 16K bytes although the actual size varies. Applications can range from 1K byte or less for a very simple application up to the size of available memory for a more sophisticated application. The data associated with an application can range from no data being stored in the card memory to a size constrained by the amount of available memory. These varied sizes of application code and data continually increase as applications become more advanced and diverse.

MULTOS as an operating system is not limited by the number of applications and associated data it can store on the card. Thus, if five applications can fit in the available memory of the card, the card user will have greatly increased functionality than if one or two applications were stored on the card. Once a card's memory is filled to its capacity, however, a new application cannot be loaded onto the card unless another application including its code and data of sufficient size can be deleted. Therefore, checking the amount of available space on the card is an important step. If there is not sufficient space, then an insufficient space response 713 will be returned to the terminal. The application loader can then decide if another existing application on the card should be deleted to make room for the new application. Deletion depends upon the card issuer having an application delete certificate from the CA. If there is sufficient space on the card, then the process continues with step 715.

An example of the testing of memory spaces in step 711 is now described. The numbers used in this example in no way limit the scope of the invention but are used only to illustrate memory space requirements. An IC card may have 16K available EEPROM when it is first manufactured. The operating system data necessary for the operating system may take up 2K of memory space. Thus, 14K would remain. An electronic purse application's code is stored in EEPROM and may take up 8K of memory space. The purse application's required data may take up an additional 4K of memory space in EEPROM. The memory space which is free for other applications would thus be 2K (16K-2K-8K-4K=2K). If a card issuer wants to load a credit/debit application whose code is 6K bytes in size onto the card in this example, the application will not fit in the memory of the IC card. Therefore, the application cannot load the new application without first removing the purse application from the card. If a new credit/debit application was loaded into EEPROM of the IC card, then it would have to overwrite other application's code or data. The application loader is prevented from doing this.

Figure 8 shows the steps performed in determining whether the card's personalization data falls within the permissible set of cards onto which the application at issue may be loaded. These steps are preferably performed during the execution of the "create" command. However, these steps may be performed at any time during the loading or deleting of an application. As described previously, the card is personalized by storing data specific to the card (MSM personalization data) including: a card ID designation specific to an individual card, the card issuer number indicating the issuer of the card, the product type of the card, such as a gold or platinum card, and the date the card was personalized. This data uniquely identifies the card apart from all other IC cards in the system.

Accordingly, applications can be selectively stored on individual cards in the IC card system on virtually any basis, including the following. An application can be loaded selectively to cards containing one or more specific card numbers. An application can be selectively loaded on one or more cards containing a specified card issuer ID. Moreover, an application can be loaded only upon one type of product specified by the particular card issuer, and/or the application can be loaded only on cards which have a specified date or series of dates of personalization. Each of the personalization data allows an application to be selectively loaded onto certain cards or groups of cards and also ensures that cards without the proper permissions will not receive the application. Personalization data types in addition to the four described can also be used as needed.

The selection of IC cards upon which a particular application may be loaded is made possible by the use of "applications permissions data" which is assigned to the application and represents at least one set of cards upon which the application may be loaded. The set may be based on virtually any factor, including one or more of the following: card numbers, card issuers, product types or personalization dates. Although the individual card's personalization data typically identify one specific number, one card issuer, one product type and one date, the application's permissions data may indicate a card number or a blanket permission, a card issuer or a blanket permission, and a number of product types and dates.

For example, a frequent loyalty program may be configured to allow its loading and use on cards in different product classes belonging to one card issuer. In addition, the application permissions data may indicate that the loyalty program can be used on gold and platinum product types if the card was issued after May, 1998. Thus, the MSM permissions check will determine if the card's individual personalization data is included in the allowed or permissible set of cards upon which the application may be loaded. If it is, the application will be loaded.

To expedite the comparison process, an alternative embodiment may include setting one or more permissions data at zero representing a blanket permission for that particular data. For instance, by placing a zero for the "card number" entry in the application permissions data or some other value indicating that all cards may be loaded regardless of their number, the system knows not to deny any cards based on their card number. Moreover, if a zero is placed in the application's permissions data "issuer ID," then all cards similarly will pass the "issuer" test comparison. This feature allows greater flexibility in selecting groups of cards. The zero indicator could also be used for other permissions data, as required.

Referring to Figure 8, each of the permissions data is checked in the order shown, but other orders could be followed because if any one of the permissions fails, the application will be prevented from being loaded on the IC card being checked. The permissions are preferably checked in the order shown. Step 801 checks if the application permissions product type set encompasses the card's product type number stored in the memory of the card. Each card product type is assigned a number by the system operator. The product types are specified for each card issuer because different card issuers will have different product types. The cards are selectively checked to ensure that applications are loaded only on cards of authorized product type. The application permissions product type set can be 32 bytes long which includes multiple acceptable product types or can be a different length depending upon the needs of the system. Using data structure 505A as an example, the operating system would check bit number 2 in the 256 bit array (32 bytes x 8 bits per byte) resulting from the 32 byte long application permissions data structure. If the permissions check fails, then the card returns a failure message to the terminal in step 803. If the product type check passes (for example, the value of bit no. 2 being 1), then the process continues with step 805.

Step 805 checks if the application permissions allowable card issuer number set encompasses the card's issuer number stored in the memory of the card or if the application permissions issuer data is zero (indicating all cards pass this individual permissions check). Each card issuer is assigned a number by the system operator and the cards are selectively checked to ensure that applications are loaded only on cards distributed by authorized card issuers. The application permissions card issuer number set can be 4 bytes long if one issuer is designated or can be longer depending upon the needs of the system. If the issuer check fails, then the card returns a failure message to the terminal in step 807. If the check passes, then the process continues with step 809.

Step 809 checks if the application permissions date set encompasses the card's data date stored in the memory of the card. The date that the IC card was personalized will be stored and will preferably include at least the month and year. The cards are selectively checked to ensure that applications are loaded only on cards with the authorized personalization date. The application permissions date set can be 32 bytes long which includes multiple dates or can be a different length depending upon the needs of the system. If the date permissions check fails, then the card returns a failure message to the terminal in step 811. If the date check passes, then the process continues with step 813.

Step 813 checks if the application permissions allowable card number set encompasses the card's ID number stored in the card memory or if the application permissions allowable card number data is zero (indicating all cards pass this individual permissions check). The testing of the permissions is performed on the card during the execution of the open, load and create commands. The application permissions card number data set can be 8 bytes long if one number is designated or can be longer depending upon the needs of the system. If the card number check fails, then the card returns a failure message to the terminal in step 815. If the check passes, then the process continues with step 817.

Summary of IC Card System's Process

Figure 9 shows the components of the system architecture for the card initialization process of an IC card in a secure multiple application IC card system. The system includes a card manufacturer 102, a personalization bureau 104, an application loader 106, the IC card 107 being initialized, the card user 109 and the certification authority 111 for the entire multiple application secure system. The card user 131 is the person or entity who will use the stored applications on the IC card. For example, a card user may prefer an IC card that contains both an electronic purse containing electronic cash (such as MONDEX™) and a credit/debit application (such as the MasterCard® EMV application) on the same IC card. The following is a description of one way in which the card user would obtain an IC card containing the desired applications in a secure manner.

The card user would contact a card issuer 113, such as a bank which distributes IC cards, and request an IC card with the two applications both residing in memory of a single IC card. The integrated circuit chip for the IC card would be manufactured by manufacturer 102 and sent to the card issuer 113 (or an entity acting on its behalf) in the form of an IC chip on a card. As discussed above (see steps 201-209), during the manufacturing process, data is transmitted 115 via a data conduit from the manufacturer 102 to card 107 and stored in IC card 107's memory. (Any of the data conduits described in this figure could be a telephone line, Internet connection or any other transmission medium.) The certification authority 111, which maintains encryption/decryption keys for the entire system, transmits 117 security data (i.e., global public key) to the manufacturer over a data conduit which is placed on the card by the manufacturer along with other data, such as the card enablement key and card identifier. The card's multiple application operating system is also stored in ROM and placed on the card by the manufacturer.

After the cards have been initially processed, they are sent to the card issuer for personalization and application loading.

The card issuer 113 performs, or has performed by another entity, two separate functions. First, the personalization bureau 104 personalizes the IC card 107 in the ways described above, and second, the application loader 106 loads the application provided the card is qualified, as described.

Regarding personalization, an individualized card key set is generated by the CA and stored on the card (see Fig. 3). The card is further given a specific identity using MSM personalization (see Fig. 3, step 307 and Fig. 5) including a card ID number, an issuer ID number identifying the card issuer which processed the card, a card product type number which is specified by the card issuer and the date upon which the personalization took place. After the card has been personalized, applications need to be loaded onto the card so that the card can perform desired functions.

The application loader 106, which could use the same terminal or data conduit as personalization bureau 104, first needs to have determined if the card is qualified to accept the application. This comparison process takes place on the card itself (as instructed by its operating system) using the permissions information. The card, if it is qualified, thus selectively loads the application onto itself based upon the card's identity and the card issuer's instructions. The application loader communicates 119 with the IC card via a terminal or by some other data conduit. After the applications have been loaded on the card, the card is delivered to the card user 109 for use.

The secure multiple application IC card system described herein allows for selective loading and deleting of applications at any point in the life cycle of the IC card after the card has been personalized. Thus, a card user could also receive a personalized card with no applications and then select a desired application over a common transmission line such as a telephone line or Internet connection.

Figure 10 is a system diagram of entities involved with the use of an IC card once it has been personalized. The system includes an IC card 151, a terminal 153, an application load/delete entity 155, the certification authority 157, a card issuer 171 and other IC cards 159 in the system. The arrows indicate communication between the respective entities. The CA 157 facilitates loading and deleting of applications. After providing the MSM permissions data and card specific keyset to the card during card enablements, the CA allows applications to be later loaded and deleted preferably by issuing an application certificate. Application specific keys are required to authenticate communication between a card and terminal. The IC card 151 also can communicate with other IC cards 159. Card issuer 171 is involved with all decisions of loading and deleting applications for a card which it issued. All communications are authenticated and transmitted securely in the system.

For instance, IC card 151 will use the following procedure to load a new application onto the card. IC card 101 is connected to terminal 153 and the terminal requests that an application be loaded. Terminal 153 contacts application load/delete entity 155 which, as a result and in conjunction with card issuer 171, sends the application code, data and application permissions data (along with any other necessary data) to terminal 153. Terminal 153 then queries card 151 to ensure it is the correct card onto which the application may be loaded. If IC card passes the checks discussed above, the application is loaded onto card 151. The CA 157 provides the application load or delete certificate that enables the application to be loaded or deleted from the card. This example shows one way to load the application, but other variations using the same principles could be performed, such as directly loading the application at the application load/delete entity 155.

The foregoing merely illustrates the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise numerous systems and methods which, although not explicitly shown or described herein, embody the principles of the invention and are thus within the spirit and scope of the invention.

For example, it will be appreciated that the MSM personalization and permissions data may not only be used for loading applications onto IC cards but also for deleting applications from said cards. The same checks involving MSM permissions and loading applications are made for deleting applications. A delete certificate from the CA authorizing the deletion of an application will control from which cards the application may be deleted. This is accomplished through the personalization data stored on each IC card and the permissions check as described herein.

Moreover, the data may also be applicable to personal computers or other units onto which applications may be loaded which are not physically loaded on cards. In addition, the application's permissions data may actually include data representative of a set or sets of cards to be excluded, instead of included -- cards that cannot be loaded with the application.

The scope of the present disclosure includes any novel feature or combination of features disclosed therein either explicitly or implicitly or any generalisation thereof irrespective of whether or not it relates to the claimed invention or mitigates any or all of the problems addressed by the present invention. The application hereby gives notice that new claims may be formulated to such features during the prosecution of this application or of any such further application derived therefrom. In particular, with reference to the appended claims, features from dependant claims may be combined with those of the independent claims in any appropriate manner and not merely in the specific combinations enumerated in the claims.

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MULTI-APPLICATION IC CARD SYSTEM

Integrated circuit ("IC") cards are becoming increasingly used for many different purposes in the world today. An IC card (also called a smart card) typically is the size of a conventional credit card which contains a computer chip including a microprocessor, read-only-memory (ROM), electrically erasable programmable read-only-memory (EEPROM), an Input/Output (I/O) mechanism and other circuitry to support the microprocessor in its operations. An IC card may contain a single application or may contain multiple independent applications in its memory. MULTOS™ is a multiple application operating system which runs on IC cards, among other platforms, and allows multiple applications to be executed on the card itself. This allows a card user to run many programs stored in the card (for example, credit/debit, electronic money/purse and/or loyalty applications) irrespective of the type of terminal (i.e., ATM, telephone and/or POS) in which the card is inserted for use.

A conventional single application IC card, such as a telephone card or an electronic cash card, is loaded with a single application at its personalization stage. That application, however, cannot be modified or changed after the card is issued even if the modification is desired by the card user or card issuer. Moreover, if a card user wanted a variety of application functions to be performed by IC cards issued to him or her, such as

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both an electronic purse and a credit/debit function, the card user would be required to carry multiple physical cards on his or her person, which would be quite cumbersome and inconvenient. If an application developer or card user desired two different applications to interact or exchange data with each other, such as a purse application interacting with a frequent flyer loyalty application, the card user would be forced to swap multiple cards in and out of the card-receiving terminal, making the transaction difficult, lengthy and inconvenient.

The Applicant has recognised therefore, that it is beneficial to store multiple applications on the same IC card. For example, a card user may have both a purse application and a credit/debit application on the same card so that the user could select which type of payment (by electronic cash or credit card) to use to make a purchase. Multiple applications could be provided to an IC card if sufficient memory exists and an operating system capable of supporting multiple applications is present on the card. Although multiple applications could be pre-selected and placed in the memory of the card during is production stage, it would also be beneficial to have the ability to load and delete applications for card post-production as needed.

The increased flexibility and power of storing multiple applications on a single card create new challenges to be overcome concerning the integrity and security of the information (including application code and associated data) exchanged between the individual card and the application provider as well as within the entire system when loading and deleting applications. The Applicant has further recognised that it would be beneficial to have the capability of the IC card system to exchange data among cards, card issuers, system operators and application

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providers securely and to load and delete applications securely at any time from either a terminal or remotely over a telephone line, internet or intranet connection or other data conduit. Because these data transmission lines are not typically secure lines, a number of security and entity-authentication techniques must be implemented to make sure that applications being sent over the transmission lines are only loaded on the intended cards.

As mentioned, it is important -- particularly where there is a continuing wide availability of new applications to the cardholder -- that the system has the capability of adding applications onto the IC card subsequent to issuance. This is highly advantageous since it protects the longevity of the IC cards; otherwise, once an application becomes outdated, the card would be useless. In this regard, to protect against the improper or undesired loading of applications onto IC cards, the Applicant has further recognised that it would be beneficial for the IC card system to have the capability of controlling the loading process and restricting, when necessary or desirable, the use of certain applications to a limited group or number of cards such that the applications are "selectively available" to the IC-cards in the system. This "selective capability" would allow the loading and deleting of applications at, for example, a desired point in time in the card's life cycle. It would also allow the loading of an application only to those cards chosen to receive the selected application.

Accordingly, it is an advantage of a preferred embodiment of the invention that it provides these important features and specifically a secure IC-card system that allows for selective availability of smart card applications which may be loaded onto IC cards.

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These and other advantages are achieved by an embodiment of the present invention which proves an IC card system comprising at least one IC card and an application to be loaded onto the card wherein the IC card contains card personalization date and the application is assigned application permissions data designating which IC card or group of IC cards upon which the application may be loaded. The system checks to determine whether the card's personalization data falls within the permissible set indicated by the application's permissions data. If it does, the application may be loaded onto the card.

In a preferred embodiment, the card personalization data is transferred onto the card by the personalization bureau after the card is manufactured. The data preferably includes data representing the card number, the issuer, product class (i.e., such as gold or platinum cards), and the date on which the card was personalized. The card further preferably contains enablement data indicating whether or not the card has been enabled with personalized data.

In a further preferred embodiment, the IC card secure system checks the enablement data prior to loading an application to determine whether or not the card has been enabled. Preferably, if the card has been enabled, the system checks if the card number, the issuer, the product class and/or the date on which the card was personalized are within the acceptable set indicated by the application's permissions data. If so, the application may be loaded onto the IC card.

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In yet another preferred embodiment, the application's permissions data may contain data representative of a blanket permission such that all cards would pass for application loading.

Further aspects, features and advantages of embodiments of the invention will become apparent from the following detailed description taken in conjunction with the accompanying figures showing illustrative embodiments of the invention, in which

Fig. 1 is block diagram illustrating the three stages in the life of a multi-application IC card in a secure system;

Fig. 2 is a block diagram illustrating the steps of the card manufacture process;

Fig. 3 is a flow diagram illustrating the steps involved in enabling each of the IC cards in the secure system;

Fig. 4 is a block diagram of an IC card chip which can be used in accordance with an embodiment of the invention;

Fig. 5 is a block diagram illustrating the data stored on the IC card as indicated in block 307 of Fig. 3;

Fig. 5A is a schematic of the data structures residing in an IC card and representing personalization data;

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Fig. 6 is a flowchart illustrating the steps of loading an application onto an IC card in the secure system;

Fig. 7 is a flow chart illustrating the checking steps as indicated in block 601 of Fig. 6;

Fig. 8 is a flowchart illustrating the steps undertaken in determining if loading of an application may proceed;

Fig. 9 is a block diagram showing the components of the system architecture for the enablement process of an IC card in a secure multi-application IC card system; and

Fig. 10 is a system diagram of entities involved with the use of the IC card once it has been personalized.

Throughout the figures, the same reference numerals and characters, unless otherwise stated, are used to denote like features, elements, components or portions of the illustrated embodiments. Moreover, while the subject invention will now be described in detail with reference to the figures, it is done so in connection with the illustrative embodiments. It is intended that changes and modifications can be made to the described embodiments without departing from the true scope and spirit of the subject invention as defined by the appended claims.

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An embodiment of the present invention provides an IC card system and process which allow the flexibility to load and delete selected applications over the lifetime of a multi-application IC card in response to the needs or desires of the card user, card issuers and/or application developers. A card user who has such a card can selectively load and delete applications as desired if allowed by the card issuer in conjunction with the system operator or Certification Authority ("CA") which controls the loading and deleting process by certifying the transfer of information relating to the process.

By allowing applications to be selectively loaded and deleted from the card, a card issuer can extend additional functionality to an individual IC card without having to issue new cards. Moreover, application developers can replace old applications with new enhanced versions, and applications residing on the same card using a common multiple application operating system may interact and exchange data in a safe and secure manner. For example, a frequent flyer loyalty program may automatically credit one frequent flyer mile to a card user's internal account for every dollar spent with an electronic purse such as the Mondex purse or with a credit/debit application. By allowing the ability to selectively load and delete applications, the card user, subject to the requirements of the card issuer, also has the option of changing loyalty programs as desired.

A card issuer or application developer may intend that a particular application be loaded on only one card for a particular card user in a card system. A regional bank may desire to have a proprietary application reside only on the cards which the bank issues. Embodiments in accordance with the present invention would allow for this selective loading and specifically allow for the prevention of loading proprietary applications onto unauthorized cards issued by others.

To achieve these desired objectives, embodiments of the present invention give each card a specific indentity by storing "card personalization data" on the card. Morover, each application to be loaded or deleted on one or more cards in the system is assigned "application permissions data" which specify the cards upon which the applications may be loaded.

The type of personalized data can vary depending upon the needs and requirements of the card system. In the preferred embodiment, described in greater detail below, the personalization data include unique card identification designation data, the card issuer, the product class or type (which is defined by the card issuer) and the date of personalization. However, not all of these data elements are required to be used and additional elements could also be included.

The application permissions data associated with an application, also described in greater detail below, can be a single value in an identity field or could include multiple values in the identity field. For example, the application permissions data in the card issuer field could represent both product class A and product class B from a certain Bank X, indicating that the application could be loaded onto cards designated as product classes A and B issued by Bank X (as indicated in the card product ID field of the card's personalization data).

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In addition, a "global value" could be stored in the issuer field (or other field) of the application permissions data indicating that all IC cards in the system regardless of who issued the card would match this permissions field. In this case, for example, a data value of zero stored in the application permissions card-issuer field will match all of the cards' personalization card-issuer fields.

Figure 1 shows the three steps involved in providing an operational multi-application IC card in a secure system. The first step is the card manufacturing step 101. The second step is the personalization step 103 where card personalization data (also called entity authentication data) is loaded onto the card. The third step is the application loading step 105 which checks to see if a card is qualified to receive an application, i.e., when the personalization data is checked against the application permissions data associated with the application to be loaded. Each of these three steps is described in detail below.

Card Manufacture

Figure 2 shows the steps necessary in manufacturing an IC card in a secure system. Step 201 manufactures the physical IC card by creating the integrated circuit on silicon and placing it on the card. The integrated circuit chip will include RAM, ROM and EEPROM memories. When the card is first manufactured, a global public key of the system operator (in this case called the Certification Authority (CA)) is stored on each card in ROM in step 203. This will allow the card to authenticate that the source of any message to it is from the CA since the public key on the card will be matched to the CA's secret key.

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More specifically, this public key stored on the card will allow the individual card to verify data signed with the CA's private key. The public key of the CA, which is stored on the card, is used only for determining if the data sent to the card was signed with the proper CA private key. This allows the card to verify the source of any message coming from the CA.

Step 205 inserts a card enablement key in a secure portion of EEPROM in the card to facilitate card specific confidentiality during enablement, and step 207 inserts a card identifier in EEPROM of the card. The identifier, which can be accessed by any terminal, will allow the system to determine the identity of the card in later processes. The identifier is freely available and will not be used to authenticate messages.

Step 209 stores the operating system code in ROM on the card including any primitives which are called or supported by the operating system. The primitives are written in native language code (e.g., assembly language) and are stored in ROM. The primitives are subroutines which may be called by the operating system or by applications residing on the card such as mathematic functions (multiply or divide), data retrieval, data manipulation or cryptographic algorithms. The primitives can be executed very quickly because they are written in the native language of the processor.

After the IC cards are manufactured, they are sent to a personalization bureau ("PB") to enable and personalize the card by storing card personalization data in the memory of the card. The terms enablement and personalization are used interchangeably herein to indicate the preparatory steps taken to allow the card to be loaded securely with

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an application. The individual cards are preferably manufactured in batches and are sent to a personalization bureau in a group for processing.

Card Enablement/Personalization

Figure 3 shows the steps of the card enablement process when the card arrives at a personalization bureau. The personalization bureau may be the card issuer (e.g., a bank or other financial institution) or may be a third party that performs the service for the card issuer. The personalization bureau configures the card to a specific user or user class.

Figure 3 specifically shows the steps taken to enable and personalize each IC card which will work within the system. The cards can be placed in a terminal which communicates with IC cards and which reads the card identifier data (previously placed on the card during the manufacturing process -- see step 207). This card identification data is read from the card in step 301. The terminal will effectively send a "get identification data" command to the card and the card will return the identification data to the terminal.

The PB typically processes a group of cards at the same time, and will first compile a list of IC card identification data for the group of cards it is personalizing. The PB then sends electronically (or otherwise) this list of identification data to the Certification Authority ("CA") which creates a personalization (or enablement) data block for each card identifier. The data block includes the card personalization data organized in a number of identity fields and an individual key set for the card, discussed below. These data blocks are then encrypted and sent to the PB in step 302. By using the

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card identification data, the PB then matches the cards with the encrypted data blocks and separately loads each data block onto the matched card. To insure that the CA controls the identity of the card and the integrity of the system, the PB never obtains knowledge of the content of the data blocks transferred. Some aspects of the personalization are requested by the card issuer to the CA in order to affect their preferred management of the cards they issue. The following additional steps are performed.

Step 303 first checks to see if an enablement bit stored in EEPROM of the card has been already set. If it already has been set, the card has already been configured and personalized and the enablement process will end as shown in step 304. A card cannot be enabled and personalized twice. If the bit has not been set, then the process continues with step 305.

In step 305, the individualized card key set for the card being enabled (which key set is generated at the CA) is stored on the card. The keys can be used later in off-card verification (i.e., to verify that the card is an authentic card). This verification is necessary to further authenticate the card as the one for which the application was intended.

Step 307 generates four different MULTOS Security Manager (MSM) characteristic data elements (otherwise referred to herein as personalization data) for the card at the CA which are used for securely and correctly loading and deleting applications from a particular card. The MSM characteristics also allow for the loading of applications on specific classes of identified cards. (These MSM characteristics are further described in connection with Figure 5.)

Other data can also be stored on the card at this time as needed by the system design such as an address table or further subroutines.

Step 311 sets the enablement bit in EEPROM of the card which indicates that the enablement process has been completed for the particular card. When this bit is set, another enablement process cannot occur on the card. This ensures that only one personalization and enablement process will occur to the card thus preventing illegal tampering of the card or altering the card by mistake. In the preferred embodiment, the enablement bit is initially not set when the card is manufactured and is set at the end of the enablement process.

Figure 4 shows an example of a block diagram of an IC card chip which has been manufactured and personalized. The IC card chip is located on an IC card for use. The IC card preferably includes a central processing unit 401, a RAM 403, a EEPROM 405, a ROM 407, a timer 409, control logic 411, an I/O ports 413 and security circuitry 415, which are connected together by a conventional data bus.

Control logic 411 in memory cards provides sufficient sequencing and switching to handle read-write access to the card's memory through the input/output ports. CPU 401 with its control logic can perform calculations, access memory locations, modify memory contents, and manage input/output ports. Some cards have a coprocessor for handling complex computations like cryptographic algorithms. Input/output ports 413 are used under the control of a CPU and control logic alone, for communications between the card and a card acceptance device. Timer 409 (which generates or provides a clock pulse) drives the control logic 411 and CPU 401 through the sequence of steps that

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accomplish memory access, memory reading or writing, processing, and data communication. A timer may be used to provide application features such as call duration. Security circuitry 415 includes fusible links that connect the input/output lines to internal circuitry as required for testing during manufacture, but which are destroyed ("blown") upon completion of testing to prevent later access. The personalization data to qualify the card is stored in a secured location of EEPROM 405. The comparing of the personalization data to applications permissions data is performed by the CPU 401.

Figure 5 shows the steps of generating and loading the four elements of the card personalization data into the memory of the IC cards, and Fig. 5A shows a schematic of bit maps for each identity field residing in the memory of an IC card containing personalization data in accordance with the present invention. Each data structure for each identity field has its own descriptor code. Step 501 loads the data structure for the identity field "card ID" called "msm_mcd_permissions_mcd_no." This nomenclature stands for MULTOS system manager _ MULTOS card device _ permissions_ MULTOS card device number. Although this number is typically 8 bytes long as shown in Fig. 5A, the data could be any length that indicates a unique number for the card. In the preferred embodiment, 2 bytes are dedicated as a signal indicator, 2 bytes comprise a MULTOS Injection Security Module ID (MISM ID) indicating which security module injected the card with its injected keys when it was manufactured, and 4 bytes comprise an Integrated Circuit Card (ICC) serial number which identifies the individual card produced at the particular MISM.

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Step 503 loads the data structure for the identity field "issuer ID" called "msm_mcd_permissions_ mcd_issuer_id." This nomenclature stands for a MULTOS card device issuer identification number. Each card issuer (such as a particular bank, financial institution or other company involved with an application) will be assigned a unique number in the card system. Each IC card in the MULTOS system will contain information regarding the card issuer which personalized the card or is responsible for the card. A card issuer will order a certain number of cards from a manufacturer and perform or have performed the personalization process as described herein. For example, a regional bank may order 5,000 cards to be distributed to its customers. The "mcd_issuer_id" data structure on these cards will indicate which issuer issued the cards. In the preferred embodiment, the data structure is 4 bytes long (as shown in Fig. 5A at 503A) to allow for many different issuers in the system although the length of the data structure can vary with the needs of the card system.

Step 505 loads the data structure for the identity field "product ID" called "msm_mcd_permissions_mcd_ issuer_product_id." This nomenclature stands for MULTOS card device issuer product identification number. Each card issuer may have different classes of products or cards which it may want to differentiate. For example, a bank could issue a regular credit card with one product ID, a gold credit card with another product ID and a platinum card with still another product ID. The card issuer may wish to load certain applications onto only one class of credit cards. A gold credit card user who pays an annual fee may be entitled to a greater variety of applications than a regular credit card user who pays no annual fee. The product ID field identifies the card as a

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particular class and will later allow the card issuer to check the product ID and only load applications onto cards which match the desired class.

Another way to differentiate products is by application type, such as by categorizing the application as financial, legal, medical and/or recreational, or by assigning particular applications to a group of cards. For example, one card issuer may have different loyalty programs available with different companies to different sets of card users. For example, a bank may have an American Airlines® loyalty program and a British Airways® loyalty program for different regions of the country dependent on where the airlines fly. The product type allows the issuer to fix the product classification of the card during the personalization process. When loading applications onto the card, the product type identification number on each card will be checked to make sure it matches the type of card onto which the issuer desires to load. The product type data structure is preferably an indexing mechanism (unlike the other personalization data structure) of 8 bits (as shown at 505A in Fig. 5A) but could be any length depending upon the needs of the card system. In the illustrated embodiment, the resulting instruction would be to locate the second bit (since the byte's indicated value is 2) in the array to be searched (see discussion of step 809 below).

Step 507 loads the data structure for the identity field data called "msm_mcd_permissions_mcd_ controls_data_ date." This nomenclature stands for the MULTOS card device controls data date or, in other words, the date on which the card was personalized so that, for example, the application loader can load cards dated only after a certain date, load cards before a certain date (e.g., for application updates) or load

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cards with a particular data date. The information can include the year, month and day of personalization or may include less information, if desired. The data_date data structure is preferably 1 byte in length (see 507A in Fig. 5A) although it could be any length depending upon the needs of the particular card system used.

Once all of the personalization data structures are loaded and stored in the card, the card has been identified by issuer, product class, date and identification number (and other data fields, if desired), and the card cannot change its identity: these fields cannot be changed in the memory of the card. If a card user wants to change the product_id stored in the card to gain access to different applications available to another product type, a new card will have to be issued to the user containing the correct personalization data. This system is consistent with a gold card member receiving a new card when the classification is changed to platinum.

After the card has been enabled and personalized by storing its individual card key set, MSM personalization characteristics and enablement bit as described in Fig. 3, the card is ready to have applications loaded into its memory.

Loading Applications

The application loading process contains a number of security and card configuration checks to ensure the secure and proper loading of an application onto the intended IC card. The application loading process is preferably performed at the personalization bureau so that the card will contain one or more applications when the card is issued. The card may contain certain common applications which will be present on every card the issuer sends out, such as an electronic purse application or a credit/debit

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application. Alternatively, the personalization bureau could send the enabled cards to a third party for the process of loading applications. The multiple application operating system stored in the ROM of each card and the card MSM personalization data is designed to allow future loading and deleting of applications after the card has been issued depending upon the desires of the particular card user and the responsible card issuer. Thus, an older version of an application stored on the IC card could be replaced with a new version of the application. An additional loyalty application could also be added to the card after it has been initially sent to the card user because the application is newly available or the user desires to use the new application. These loading and deleting functions for applications can be performed directly by a terminal or may be performed over telephone lines, data lines, a network such as the Internet or any other way of transmitting data between two entities. In the present IC card system, the process of transmitting the application program and data ensures that only IC cards containing the proper personalization data and which fit on application permissions profile will be qualified and receive the corresponding application program and data.

Figure 6 shows the preferred steps performed in loading an application onto an IC card in the MULTOS IC card system. For this example, the personalization bureau is loading an application from a terminal which enabled the same card. Step 601 performs an "open command" initiated by the terminal which previews the card to make sure the card is qualified to accept the loading of a specific application. The open command provides the card with the application's permissions data, the application's size, and instructs the card to determine (1) if the enablement bit is set indicating the card

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has been personalized; (2) whether the application code and associated data will fit in the existing memory space on the card; and (3) whether the personalization data assigned to the application to be loaded allows for the loading of the application onto the particular card at issue. The open command could also make additional checks as required by the card system. These checking steps during the open command execution will be described in detail in conjunction with Figure 7.

After the open command has been executed, the application loader via the terminal will be advised if the card contains the proper identification personalization data and if enough room exists in the memory of the card for the application code and related data. If there is insufficient memory, then a negative response is returned by the card and the process is abended (abnormally ended). If the identification personalization data does not match the applications permissions data, a warning response is given in step 603, but the process continues to the load and create steps. Alternatively, if there is no match, the process may automatically be abended. If a positive response is returned by the card to the terminal in step 605, the application loader preferably proceeds to next steps. The open command allows the application to preview the card before starting any transfer of the code and data.

Step 607 then loads the application code and data onto the IC card into EEPROM. The actual loading occurs in conjunction with create step 609 which completes the loading process and enables the application to execute on the IC card after it is loaded. The combination of the open, load and create commands are sent by the terminal, or another application provider source, to the IC card to perform the application

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loading process. The operating system in the IC cards is programmed to perform a specific set of instructions with respect to each of these commands so that the IC card will communicate with and properly carry out the instructions from the terminal.

Step 609 performs the create command which at least: (1) checks if an application load certificate is signed (encrypted) by the CA and therefore authenticates the application as a proper application for the system; and (2) checks the card personalization data stored on the card against the permissions profile for the application to be loaded to qualify the card for loading. It may do other checks as required. If one of the checks fails, then a failure response 610 is given and the process aborts. The application after it has passed these checks will be loaded into the memory of the card.

Figure 7 shows the various steps of the open step 601 of Fig. 6 in more detail. Step 701 determines if the enablement (i.e., control) bit is set. This bit is set when the card has completed its personalization process and has been assigned its personalization data. An application can be loaded on an IC card in the card system only if the card contains the personalization data. If the enablement bit is not set, the card has not been personalized and therefore the card returns a negative response 703 to the terminal. If the enablement bit is set, then the card has been enabled and the test conditions continue with step 711.

Step 711 checks if there is sufficient space in the memory on the card to store the application code and its associated data. Applications will typically have associated data related to their functions. This data will be used and manipulated when the application is run. Storage space in the memory of an IC card is a continuing concern due to the relatively large physical space required for EEPROM and how it fits in the integrated circuit which is desired to be small enough to fit on a credit card sized card. An example of the size of a preset EEPROM on an IC card is 16K bytes although the actual size varies. Applications can range from 1K byte or less for a very simple application up to the size of available memory for a more sophisticated application. The data associated with an application can range from no data being stored in the card memory to a size constrained by the amount of available memory. These varied sizes of application code and data continually increase as applications become more advanced and diverse.

MULTOS as an operating system is not limited by the number of applications and associated data it can store on the card. Thus, if five applications can fit in the available memory of the card, the card user will have greatly increased functionality than if one or two applications were stored on the card. Once a card's memory is filled to its capacity, however, a new application cannot be loaded onto the card unless another application including its code and data of sufficient size can be deleted. Therefore, checking the amount of available space on the card is an important step. If there is not sufficient space, then an insufficient space response 713 will be returned to the terminal. The application loader can then decide if another existing application on the card should be deleted to make room for the new application. Deletion depends upon the card issuer having an application delete certificate from the CA. If there is sufficient space on the card, then the process continues with step 715.

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An example of the testing of memory spaces in step 711 is now described. The numbers used in this example in no way limit the scope of the invention but are used only to illustrate memory space requirements. An IC card may have 16K available EEPROM when it is first manufactured. The operating system data necessary for the operating system may take up 2K of memory space. Thus, 14K would remain. An electronic purse application's code is stored in EEPROM and may take up 8K of memory space. The purse application's required data may take up an additional 4K of memory space in EEPROM. The memory space which is free for other applications would thus be 2K (16K-2K-8K-4K=2K). If a card issuer wants to load a credit/debit application whose code is 6K bytes in size onto the card in this example, the application will not fit in the memory of the IC card. Therefore, the application cannot load the new application without first removing the purse application from the card. If a new credit/debit application was loaded into EEPROM of the IC card, then it would have to overwrite other application's code or data. The application loader is prevented from doing this.

Figure 8 shows the steps performed in determining whether the card's personalization data falls within the permissible set of cards onto which the application at issue may be loaded. These steps are preferably performed during the execution of the "create" command. However, these steps may be performed at any time during the loading or deleting of an application. As described previously, the card is personalized by storing data specific to the card (MSM personalization data) including: a card ID designation specific to an individual card, the card issuer number indicating the issuer of the card, the product type of the card, such as a gold or platinum card, and the date the

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card was personalized. This data uniquely identifies the card apart from all other IC cards in the system.

Accordingly, applications can be selectively stored on individual cards in the IC card system on virtually any basis, including the following. An application can be loaded selectively to cards containing one or more specific card numbers. An application can be selectively loaded on one or more cards containing a specified card issuer ID. Moreover, an application can be loaded only upon one type of product specified by the particular card issuer, and/or the application can be loaded only on cards which have a specified date or series of dates of personalization. Each of the personalization data allows an application to be selectively loaded onto certain cards or groups of cards and also ensures that cards without the proper permissions will not receive the application. Personalization data types in addition to the four described can also be used as needed.

The selection of IC cards upon which a particular application may be loaded is made possible by the use of "applications permissions data" which is assigned to the application and represents at least one set of cards upon which the application may be loaded. The set may be based on virtually any factor, including one or more of the following: card numbers, card issuers, product types or personalization dates. Although the individual card's personalization data typically identify one specific number, one card issuer, one product type and one date, the application's permissions data may indicate a card numbers or a blanket permission, a card issuer or a blanket permission, and a number of product types and dates.

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For example, a frequent loyalty program may be configured to allow its loading and use on cards in different product classes belonging to one card issuer. In addition, the application permissions data may indicate that the loyalty program can be used on gold and platinum product types if the card was issued after May, 1998. Thus, the MSM permissions check will determine if the card's individual personalization data is included in the allowed or permissible set of cards upon which the application may be loaded. If it is, the application will be loaded.

To expedite the comparison process, an alternative embodiment may include setting one or more permissions data at zero representing a blanket permission for that particular data. For instance, by placing a zero for the "card number" entry in the application permissions data or some other value indicating that all cards may be loaded regardless of their number, the system knows not to deny any cards based on their card number. Moreover, if a zero is placed in the application's permissions data "issuer ID," then all cards similarly will pass the "issuer" test comparison. This feature allows greater flexibility in selecting groups of cards. The zero indicator could also be used for other permissions data, as required.

Referring to Figure 8, each of the permissions data is checked in the order shown, but other orders could be followed because if any one of the permissions fails, the application will be prevented from being loaded on the IC card being checked. The permissions are preferably checked in the order shown. Step 801 checks if the application permissions product type set encompasses the card's product type number stored in the memory of the card. Each card product type is assigned a number by the

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system operator. The product types are specified for each card issuer because different card issuers will have different product types. The cards are selectively checked to ensure that applications are loaded only on cards of authorized product type. The application permissions product type set can be 32 bytes long which includes multiple acceptable product types or can be a different length depending upon the needs of the system. Using data structure 505A as an example, the operating system would check bit number 2 in the 256 bit array (32 bytes x 8 bits per byte) resulting from the 32 byte long application permissions data structure. If the permissions check fails, then the card returns a failure message to the terminal in step 803. If the product type check passes (for example, the value of bit no. 2 being 1), then the process continues with step 805.

Step 805 checks if the application permissions allowable card issuer number set encompasses the card's issuer number stored in the memory of the card or if the application permissions issuer data is zero (indicating all cards pass this individual permissions check). Each card issuer is assigned a number by the system operator and the cards are selectively checked to ensure that applications are loaded only on cards distributed by authorized card issuers. The application permissions card issuer number set can be 4 bytes long if one issuer is designated or can be longer depending upon the needs of the system. If the issuer check fails, then the card returns a failure message to the terminal in step 807. If the check passes, then the process continues with step 809.

Step 809 checks if the application permissions date set encompasses the card's data date stored in the memory of the card. The date that the IC card was personalized will be stored and will preferably include at least the month and year. The

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cards are selectively checked to ensure that applications are loaded only on cards with the authorized personalization date. The application permissions date set can be 32 bytes long which includes multiple dates or can be a different length depending upon the needs of the system. If the date permissions check fails, then the card returns a failure message to the terminal in step 811. If the date check passes, then the process continues with step 813.

Step 813 checks if the application permissions allowable card number set encompasses the card's ID number stored in the card memory or if the application permissions allowable card number data is zero (indicating all cards pass this individual permissions check). The testing of the permissions is performed on the card during the execution of the open, load and create commands. The application permissions card number data set can be 8 bytes long if one number is designated or can be longer depending upon the needs of the system. If the card number check fails, then the card returns a failure message to the terminal in step 815. If the check passes, then the process continues with step 817.

Summary of IC Card System's Process

Figure 9 shows the components of the system architecture for the card initialization process of an IC card in a secure multiple application IC card system. The system includes a card manufacturer 102, a personalization bureau 104, an application loader 106, the IC card 107 being initialized, the card user 109 and the certification authority 111 for the entire multiple application secure system. The card user 131 is the

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person or entity who will use the stored applications on the IC card. For example, a card user may prefer an IC card that contains both an electronic purse containing electronic cash (such as MONDEX™) and a credit/debit application (such as the MasterCard® EMV application) on the same IC card. The following is a description of one way in which the card user would obtain an IC card containing the desired applications in a secure manner.

The card user would contact a card issuer 113, such as a bank which distributes IC cards, and request an IC card with the two applications both residing in memory of a single IC card. The integrated circuit chip for the IC card would be manufactured by manufacturer 102 and sent to the card issuer 113 (or an entity acting on its behalf) in the form of an IC chip on a card. As discussed above (see steps 201-209), during the manufacturing process, data is transmitted 115 via a data conduit from the manufacturer 102 to card 107 and stored in IC card 107's memory. (Any of the data conduits described in this figure could be a telephone line, Internet connection or any other transmission medium.) The certification authority 111, which maintains encryption/decryption keys for the entire system, transmits 117 security data (i.e., global public key) to the manufacturer over a data conduit which is placed on the card by the manufacturer along with other data, such as the card enablement key and card identifier. The card's multiple application operating system is also stored in ROM and placed on the card by the manufacturer. After the cards have been initially processed, they are sent to the card issuer for personalization and application loading.

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The card issuer 113 performs, or has performed by another entity, two separate functions. First, the personalization bureau 104 personalizes the IC card 107 in the ways described above, and second, the application loader 106 loads the application provided the card is qualified, as described.

Regarding personalization, an individualized card key set is generated by the CA and stored on the card (see Fig. 3). The card is further given a specific identity using MSM personalization (see Fig. 3, step 307 and Fig. 5) including a card ID number, an issuer ID number identifying the card issuer which processed the card, a card product type number which is specified by the card issuer and the date upon which the personalization took place. After the card has been personalized, applications need to be loaded onto the card so that the card can perform desired functions.

The application loader 106, which could use the same terminal or data conduit as personalization bureau 104, first needs to have determined if the card is qualified to accept the application. This comparison process takes place on the card itself (as instructed by its operating system) using the permissions information. The card, if it is qualified, thus selectively loads the application onto itself based upon the card's identity and the card issuer's instructions. The application loader communicates 119 with the IC card via a terminal or by some other data conduit. After the applications have been loaded on the card, the card is delivered to the card user 109 for use.

The secure multiple application IC card system described herein allows for selective loading and deleting of applications at any point in the life cycle of the IC card after the card has been personalized. Thus, a card user could also receive a personalized

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card with no applications and then select a desired application over a common transmission line such as a telephone line or Internet connection.

Figure 10 is a system diagram of entities involved with the use of an IC card once it has been personalized. The system includes an IC card 151, a terminal 153, an application load/delete entity 155, the certification authority 157, a card issuer 171 and other IC cards 159 in the system. The arrows indicate communication between the respective entities. The CA 157 facilitates loading and deleting of applications. After providing the MSM permissions data and card specific keyset to the card during card enablements, the CA allows applications to be later loaded and deleted preferably by issuing an application certificate. Application specific keys are required to authenticate communication between a card and terminal. The IC card 151 also can communicate with other IC cards 159. Card issuer 171 is involved with all decisions of loading and deleting applications for a card which it issued. All communications are authenticated and transmitted securely in the system.

For instance, IC card 151 will use the following procedure to load a new application onto the card. IC card 101 is connected to terminal 153 and the terminal requests that an application be loaded. Terminal 153 contacts application load/delete entity 155 which, as a result and in conjunction with card issuer 171, sends the application code, data and application permissions data (along with any other necessary data) to terminal 153. Terminal 153 then queries card 151 to ensure it is the correct card onto which the application may be loaded. If IC card passes the checks discussed above, the application is loaded onto card 151. The CA 157 provides the application load or delete certificate that enables the application to be loaded or deleted from the card. This example shows one way to load the application, but other variations using the same principles could be performed, such as directly loading the application at the application load/delete entity 155.

The foregoing merely illustrates the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise numerous systems and methods which, although not explicitly shown or described herein, embody the principles of the invention and are thus within the spirit and scope of the invention.

For example, it will be appreciated that the MSM personalization and permissions data may not only be used for loading applications onto IC cards but also for deleting applications from said cards. The same checks involving MSM permissions and loading applications are made for deleting applications. A delete certificate from the CA authorizing the deletion of an application will control from which cards the application may be deleted. This is accomplished through the personalization data stored on each IC card and the permissions check as described herein.

Moreover, the data may also be applicable to personal computers or other units onto which applications may be loaded which are not physically loaded on cards. In addition, the application's permissions data may actually include data representative of a set or sets of cards to be excluded, instead of included -- cards that cannot be loaded with the application.

The scope of the present disclosure includes any novel feature or combination of features disclosed therein either explicitly or implicitly or any generalisation thereof irrespective of whether or not it relates to the claimed invention or mitigates any or all of the problems addressed by the present invention. The applicant hereby gives notice that new claims may be formulated to such features during the prosecution of this application or of any such further application derived therefrom. In particular, with reference to the appended claims, features from dependent claims may be combined with those of the independent claims in any appropriate manner and not merely in the specific combinations enumerated in the claims.

CLAIMS:

1. An IC card system comprising at least one IC card, an application to be loaded onto said card and means for determining whether said card is qualified to accept the loading of said application onto said card.

2. The IC card system of claim 1, wherein said IC card contains card personalization data, and said application is assigned application permissions data representing at least one set of IC cards upon which said application may be loaded.

3. The IC card system of claim 2, wherein said determining means compares said card personalization data with said application permissions data.

4. The IC card system of claim 3, wherein whether said application is loaded onto said IC card depends on the result of said comparison, such that in the event the card personalization data matches said permissions data set the card is qualified and the application is loaded.

5. The IC card system of any of claims 2 to claim 4, wherein said personalization data comprises data representative of a unique card identification designation.

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6. The IC card system of any of claims 2 to claim 5, wherein said personalization data comprises data representative of a card issuer.

7. The IC card system of any of claims 2 to claim 6, wherein said personalization data comprises data representative of a product class.

8. The IC card system of any of claims 2 to claim 7, wherein said personalization data comprises data representative of a date.

9. An IC card system comprising at least one IC card and an application, wherein said IC card contains personalization data representative of that card and said application is assigned a permissions data set representing at least one IC card upon which said application may be loaded, said system further comprising means for determining whether said personalization data falls within said permissions data set.

10. The IC card system of claim 9 wherein said application is loaded onto said IC card in the event said determining means determines that said personalization data falls within said set.

11. The IC card system of claim 9 or claim 10 wherein said personalization data comprises data representing a card identification designation, and an issuer of said card.

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12. The IC card system of any of claims 9 to claim 11 wherein said personalization data comprises data representing a product class and a date.

13. The IC card system of any of claims 9 to 12 wherein said permissions data set includes a plurality of card identification designations.

14. The IC card system of any of claims 9 to 13 wherein said permissions data set includes one or more issuers of IC cards.

15. The IC card system of any of claims 9 to 14 wherein said permissions data set includes one or more product classes.

16. The IC card system of any of claims 9 to 15 wherein said permissions data set includes a plurality range of dates.

17. The IC card system of any of claims 9 to 16 wherein said permissions data set includes all IC cards which attempt to load the application.

18. An IC card system comprising at least one IC card, an application to be loaded onto said card and means for enabling said card to be loaded with said application.

19. The IC card system of claim 18 wherein said enabling means comprises means for storing personalization data onto said card.

20. The IC card system of claim 18 wherein said enabling means comprises means for setting an enablement bit.

21. The IC card system of claim 19 wherein said enabling means comprises means for setting an enablement bit.

22. The IC card system of claim 20 further comprising means for checking the enablement bit prior to enabling said IC card to determine whether or not said card has already been enabled.

23. The IC card system of claim 21 further comprising means for checking the enablement bit prior to enabling said IC card to determine whether or not said card has already been enabled.

24. A process for loading an application onto an IC card comprising the step of determining whether said IC card is qualified to accept the loading of said application onto said card.

25. The process of claim 24 wherein said determining step includes the steps of: providing said card with personalization data;

assigning to said application permissions data representing at least one set of IC cards upon which said application may be loaded;

comparing said personalization data with said permissions data; and

loading said application onto said IC card provided said personalization data falls within said set of cards upon which said application may be loaded.

26. The process of claim 25, wherein said personalization data comprises data representative of a card identification designation.

27. The process of claim 25 or claim 26, wherein said personalization data comprises data representative of a card issuer.

28. The process of any of claims 25 to claim 27, wherein said personalization data comprises data representative of a product class.

29. The process of any of claims 25 to claim 28. wherein said personalization data comprises data representative of a date.

30. The process of any of claims 25 to claim 29 further comprising the first step of enabling said card to be loaded with said application.

31. The process of claim 30 wherein said enabling step includes the step of storing personalization data onto said card.

32. The process of claim 30 wherein said enabling step includes the step of setting an enablement bit indicating that the card has been enabled.

33. The process of claim 31 wherein said enabling step further includes the step of setting an enablement bit indicating that the card has been enabled.

34. The process of claim 32 wherein prior to said enabling step a checking step is performed to determine whether said card has been enabled.

35. The process of claim 33 wherein prior to said enabling step a checking step is performed to determine whether said card has been enabled.

36. A process for deleting an application from an IC card comprising the step of determining whether said IC card is qualified to delete said application based upon permissions data associated with said application.

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37. The process of claim 36 wherein said determining step includes the steps of:

providing said card with personalization data;

assigning to said application permissions data representing at least one set of IC cards from which said application may be deleted;

comparing said personalization data with said permissions data; and

deleting said application from said IC card provided said personalization data falls within said set of cards from which said application may be deleted.

38. The process of claim 37, wherein said personalization data comprises data representative of a card identification designation.

39. The process of claim 37 or claim 38, wherein said personalization data comprises data representative of a card issuer.

40. The process of any of claims 37 to claim 39, wherein said personalization data comprises data representative of a product class.

41. The process of any of claims 37 to claim 40, wherein said personalization data further comprises data representative of a date.

42. An IC card system comprising at least one IC card, an application to be deleted from said card and means for determining whether said card is qualified to delete said application from said card.

43. The IC card system of claim 42, wherein said IC card contains card personalization data, and said application is assigned application permissions data set representing at least one set of IC cards from which said application may be deleted.

44. The IC card system of claim 43, wherein said determining means compares said card personalization data with said application permissions data.

45. The IC card system of claim 44, wherein whether said application is deleted from said IC card depends on the result of said comparison, such that in the event the card personalization data matches said permissions data set the card is qualified and the application is deleted.

ABSTRACT ANNEX A TO THE DESCRIPTION

Multi-Application IC Card System

A multi-application IC card system is disclosed having selective application loading and deleting capability. Prior to loading an application onto an IC card a test is conducted to determine if the card is qualified to receive the application using personalization data stored on the card and comparing it with permissions data associated with the application indicating one or more sets of cards upon which the application may be loaded. If the personalization data of the card falls within the allowable set of permissions for that application then the card may be loaded with the application. Preferably, the personalization data includes data representative of the card number, issuer, a product class and the date on which the card is personalized.

WE CLAIM:

1. A multiple application card system comprising:

a certification authority for which a public and private key pair are generated;

at least one integrated circuit card including at manufacture said public key of said certification authority and a card identifier for uniquely identifying each said card;

means for creating at said certification authority a personalization data block for at least one card identifier, means for encrypting said personalization data block and forwarding said encrypted data block to a personalization bureau;

means for loading at said personalization bureau said encrypted data block on said card having the card identifier matching said encrypted personalization data block;

means for determining based at least on said encrypted personalization data block whether one of said integrated circuit cards is qualified to accept the loading of a specific application;

means for authenticating said application for loading onto said card by using said public key of said certification authority; and

loading means responsive to said determining and authenticating means for securely loading said application onto said card.

2. The system of claim 1, further comprising personalization means for enabling at least one of said cards at said personalization bureau.

3. The system of claim 1 or claim 2, wherein said at least one integrated circuit card further comprises memory means for storing an operating system for instructing said determining means, authentication means and said loading means.

4. The system of any of claims 1 to 3 wherein said at least one integrated circuit card further comprises a card enablement key for facilitating card specific confidentiality.

5. The system of claim 2 or any preceding claim dependent on claim 2 wherein said personalization means comprises means for compiling a list of said card identifiers and means for forwarding said list to said authority.

6. The system of any of claims 1 to claim 5 wherein said personalization data block comprises card personalization data and an individual key set.

7. The system of any preceding claim dependent on claim 4 claim 6 further including means for checking whether said card enablement key has been set, and wherein said means for loading said encrypted data block only loads said block in the event said enablement key has not been set, and wherein

said card enablement key is set upon loading said encrypted data block.

8. A multiple application card system comprising:

one or more integrated circuit cards each including at manufacture a public key for authenticating the source of any message to it from an authority holding a corresponding secret key, a card enablement key for facilitating card specific confidentiality, a card identifier for uniquely identifying each card, and memory storing an operating system;

personalization means for enabling said card at a personalization bureau, said personalization means including means for compiling a list of said card identifiers and means for forwarding said list to said authority;

means for creating at said authority a personalization data block for each card identifier forwarded to said authority, said data block including card personalization data and an individual key set for each of said cards;

means for encrypting each of said data blocks and means for forwarding said encrypted data blocks to said personalization bureau;

means for checking whether said card enablement key has been set and, if not, for matching said card identifiers with said encrypted data blocks, loading said encrypted data block on its matched corresponding card, and setting said enablement key;

means for determining whether said card is qualified to accept the loading of a specific application; checking means for authenticating said specific application to be loaded by checking whether said application has been signed by said authority; and

means responsive to said determining and checking means for loading said one or more specific applications.

9. A method for loading one or more applications on an integrated circuit card comprising the steps of:

transmitting security data including a public key of a certification authority onto an integrated circuit card;

creating at said certification authority a personalization data block for said card, encrypting said data block and forwarding said encrypted data block to a personalization bureau;

loading said encrypted data block onto said card;

determining based at least on said encrypted data block whether said card is qualified to accept the loading of a specific application;

authenticating said application for loading onto said card by using said public key;

loading said application in the event said card is qualified and said application is authenticated.

10. A method for deleting one or more applications from an integrated circuit card comprising the steps of:

transmitting security data including a public key of a certification authority onto an integrated circuit card;

creating at said certification authority a personalization data block for said card, encrypting said data block and forwarding said encrypted data block to a personalization bureau;

loading said encrypted data block onto said card;

determining based at least on said encrypted data block whether said card is qualified to accept the deleting of a specific application;

deleting said application in the event said card is qualified.

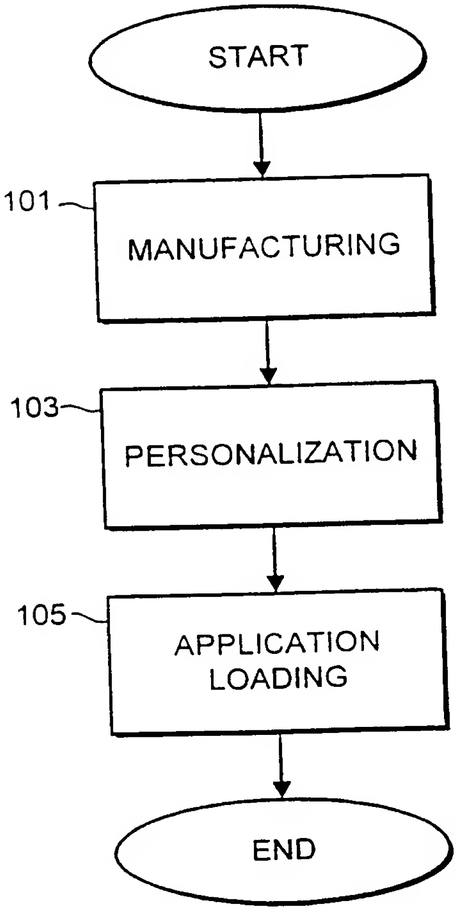
START
101
MANUFACTURING
103
PERSONALIZATION
105
APPLICATION LOADING
END

FIG. 1

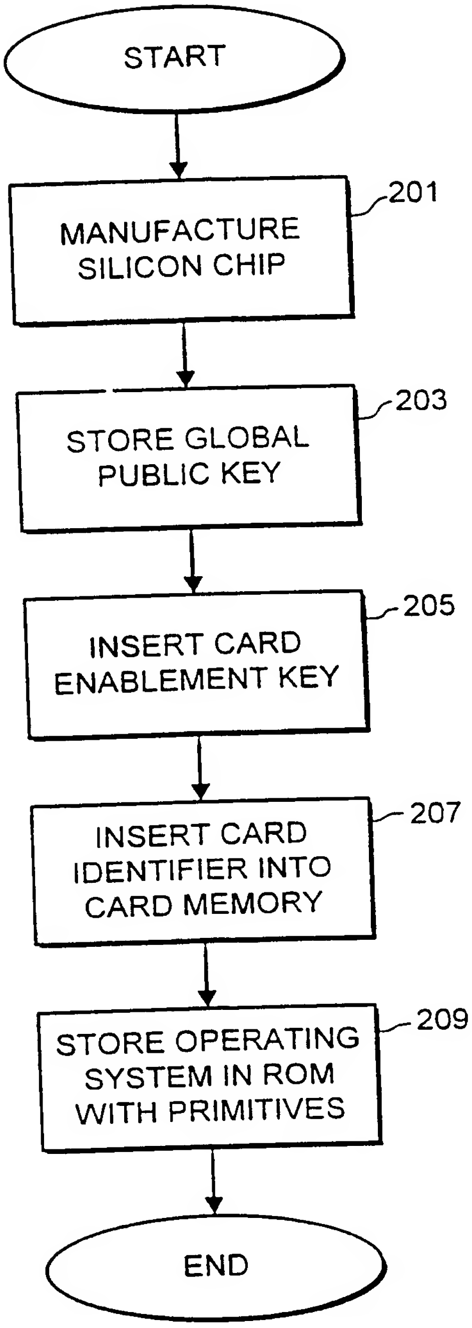
START
MANUFACTURE SILICON CHIP
201
STORE GLOBAL PUBLIC KEY
203
INSERT CARD ENABLEMENT KEY
205
INSERT CARD IDENTIFIER INTO CARD MEMORY
207
STORE OPERATING SYSTEM IN ROM WITH PRIMITIVES
209
END

FIG. 2

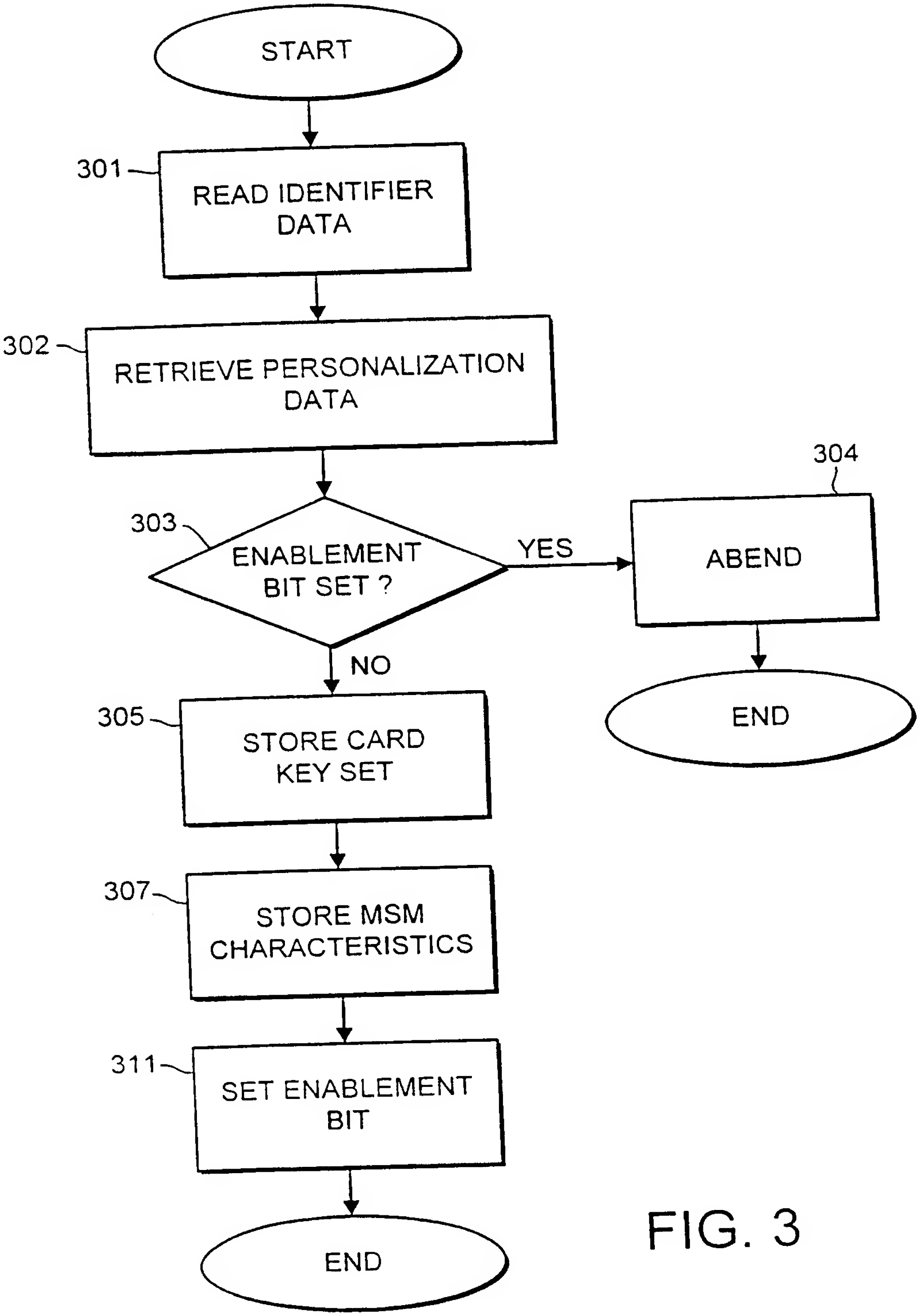
START
301
READ IDENTIFIER DATA
302
RETRIEVE PERSONALIZATION DATA
303
ENABLEMENT BIT SET ?
YES
304
ABEND
END
NO
305
STORE CARD KEY SET
307
STORE MSM CHARACTERISTICS
311
SET ENABLEMENT BIT
END

FIG. 3

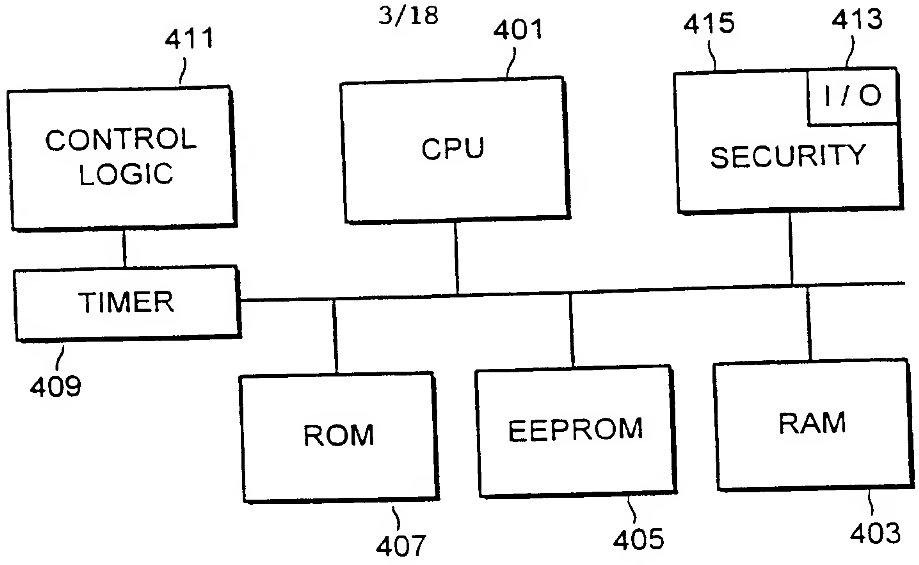
411
CONTROL LOGIC
401
CPU
415
413
I / O
SECURITY
TIMER
409
ROM
407
EEPROM
405
RAM
403

FIG. 4

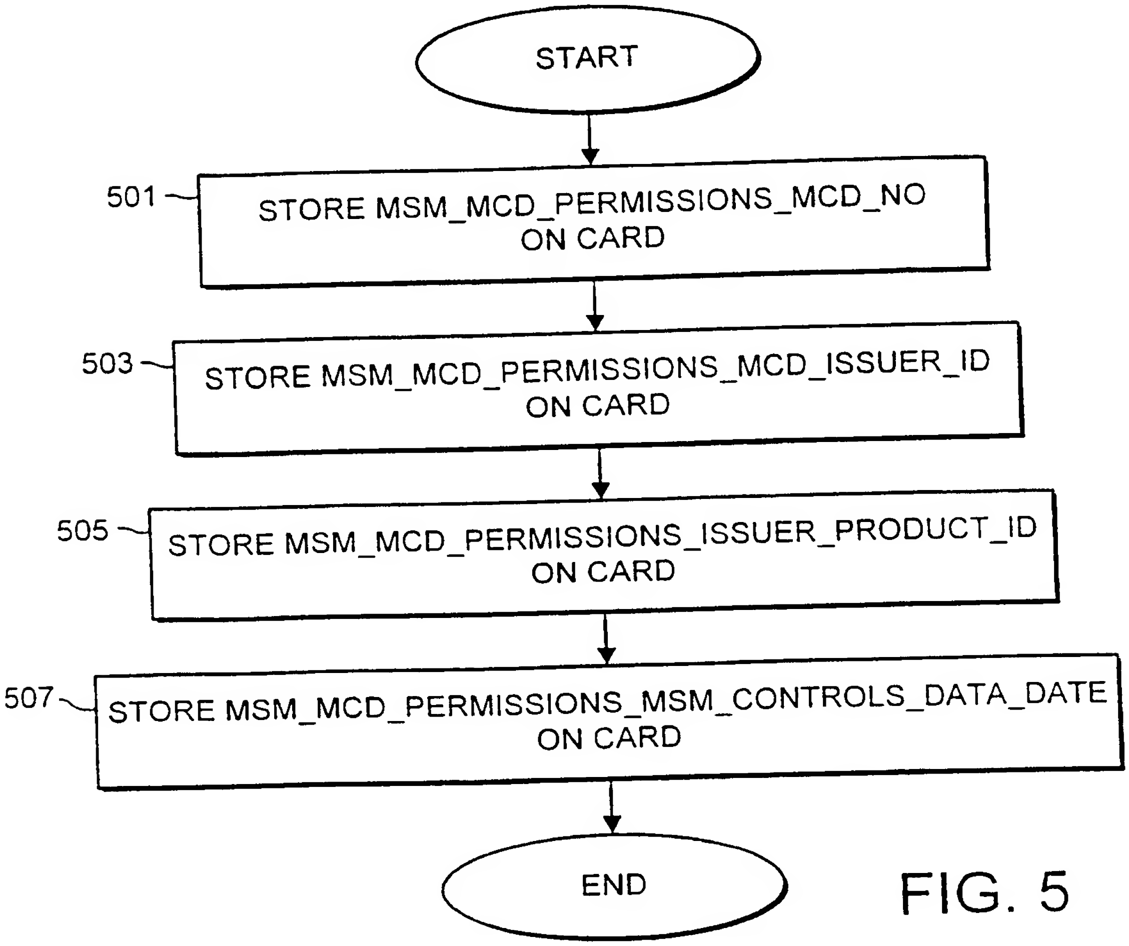
START
501
STORE MSM_MCD_PERMISSIONS_MCD_NO ON CARD
503
STORE MSM_MCD_PERMISSIONS_MCD_ISSUER_ID ON CARD
505
STORE MSM_MCD_PERMISSIONS_ISSUER_PRODUCT_ID ON CARD
507
STORE MSM_MCD_PERMISSIONS_MSM_CONTROLS_DATA_DATE ON CARD
END

FIG. 5

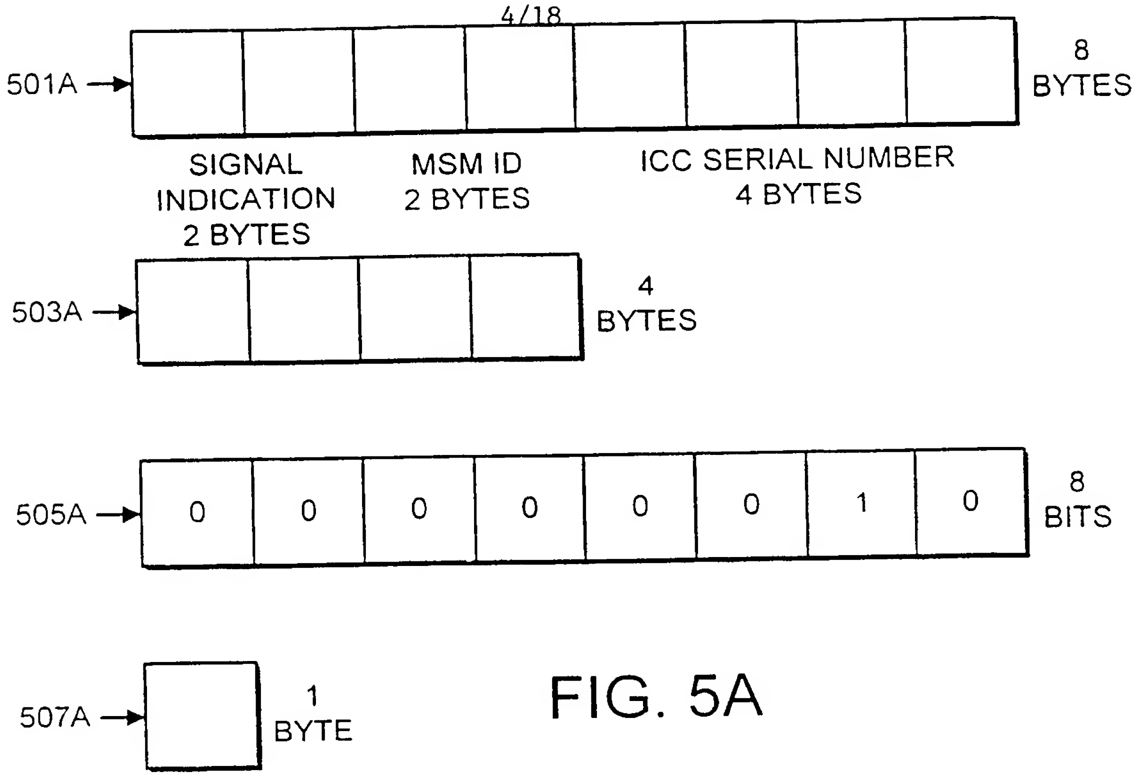
501A
8 BYTES
SIGNAL INDICATION 2 BYTES
MSM ID 2 BYTES
ICC SERIAL NUMBER 4 BYTES
503A
4 BYTES
505A
0
0
0
0
0
0
1
0
8 BITS
507A
1 BYTE

FIG. 5A

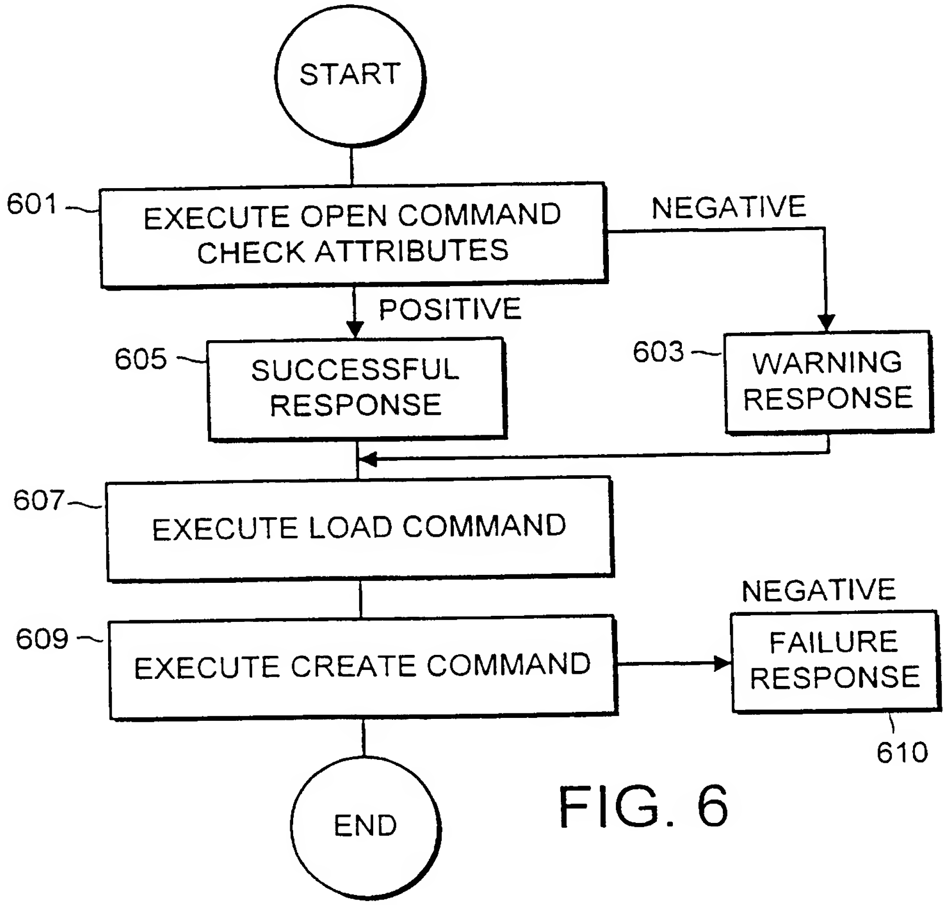
START
601
EXECUTE OPEN COMMAND CHECK ATTRIBUTES
NEGATIVE
POSITIVE
605
SUCCESSFUL RESPONSE
603
WARNING RESPONSE
607
EXECUTE LOAD COMMAND
NEGATIVE
609
EXECUTE CREATE COMMAND
FAILURE RESPONSE
610
END

FIG. 6

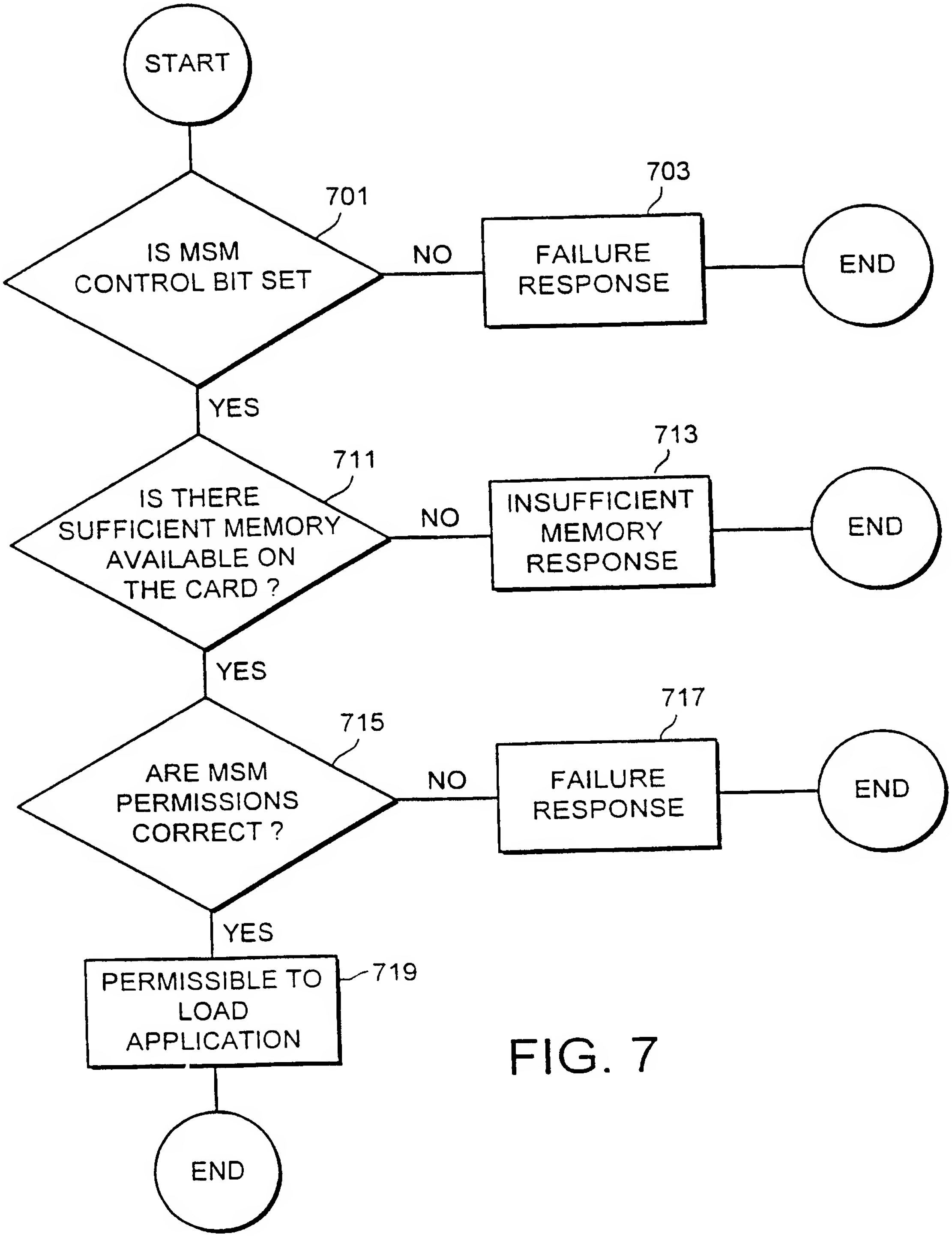
START
IS MSM CONTROL BIT SET
701
NO
FAILURE RESPONSE
703
END
YES
IS THERE SUFFICIENT MEMORY AVAILABLE ON THE CARD ?
711
NO
INSUFFICIENT MEMORY RESPONSE
713
END
YES
ARE MSM PERMISSIONS CORRECT ?
715
NO
FAILURE RESPONSE
717
END
YES
PERMISSIBLE TO LOAD APPLICATION
719
END

FIG. 7

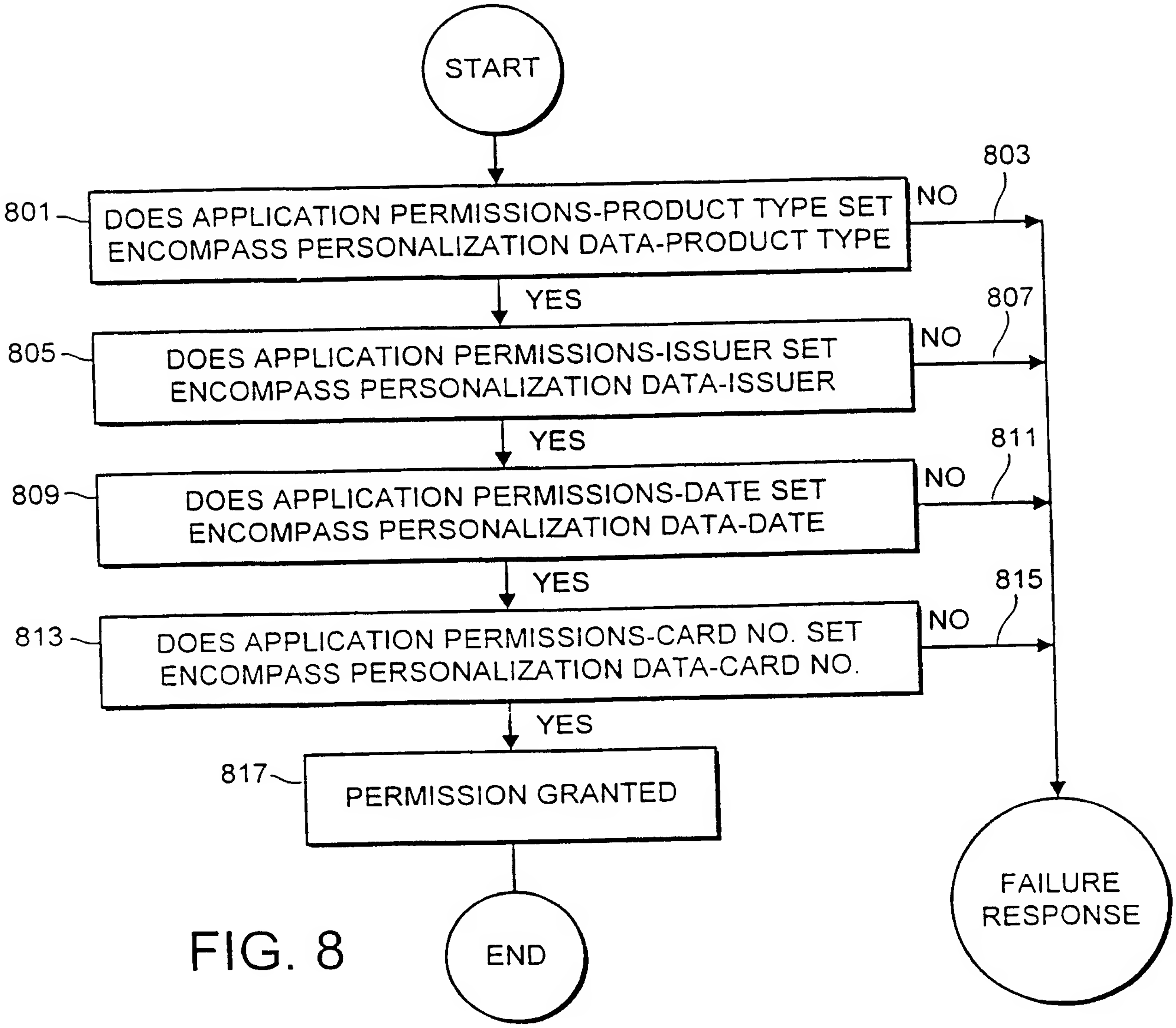
START
801
DOES APPLICATION PERMISSIONS-PRODUCT TYPE SET ENCOMPASS PERSONALIZATION DATA-PRODUCT TYPE
NO
803
YES
805
DOES APPLICATION PERMISSIONS-ISSUER SET ENCOMPASS PERSONALIZATION DATA-ISSUER
NO
807
YES
809
DOES APPLICATION PERMISSIONS-DATE SET ENCOMPASS PERSONALIZATION DATA-DATE
NO
811
YES
813
DOES APPLICATION PERMISSIONS-CARD NO. SET ENCOMPASS PERSONALIZATION DATA-CARD NO.
NO
815
YES
817
PERMISSION GRANTED
END
FAILURE RESPONSE

FIG. 8

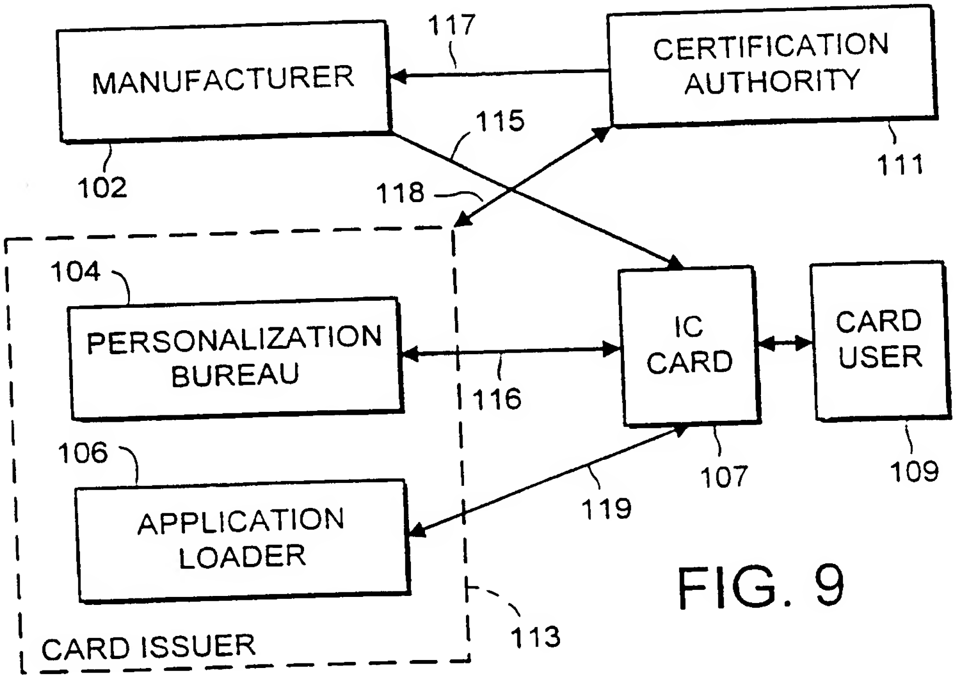
MANUFACTURER
102
117
CERTIFICATION AUTHORITY
111
115
118
104
PERSONALIZATION BUREAU
116
IC CARD
107
CARD USER
109
106
APPLICATION LOADER
119
CARD ISSUER
113

FIG. 9

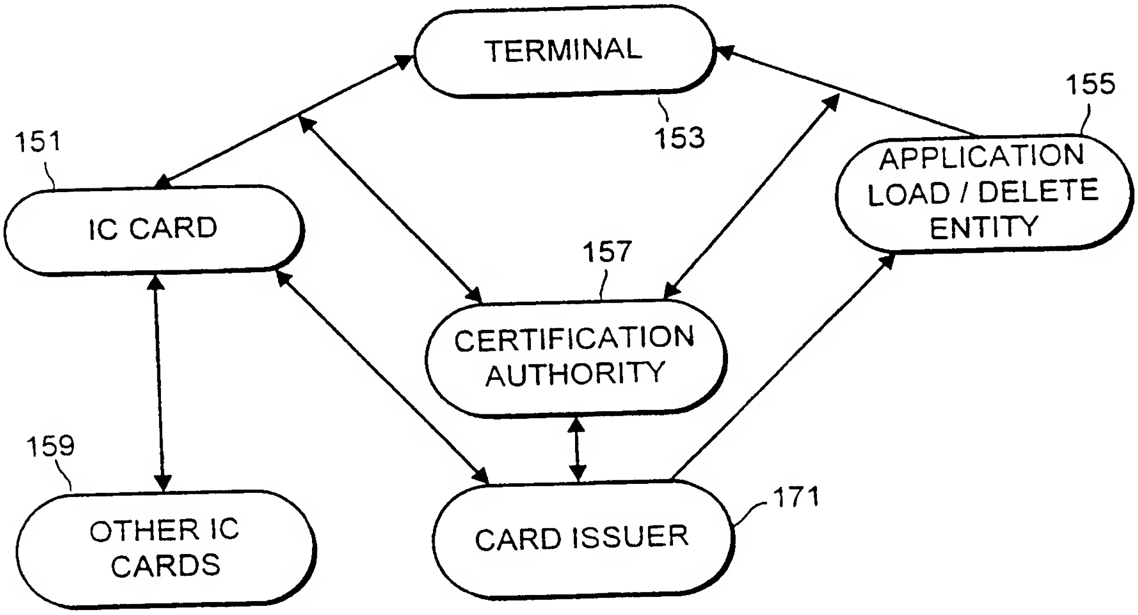
TERMINAL
153
155
APPLICATION LOAD / DELETE ENTITY
151
IC CARD
157
CERTIFICATION AUTHORITY
159
OTHER IC CARDS
CARD ISSUER
171

FIG. 10

ANNEX A TO THE DRAWINGS

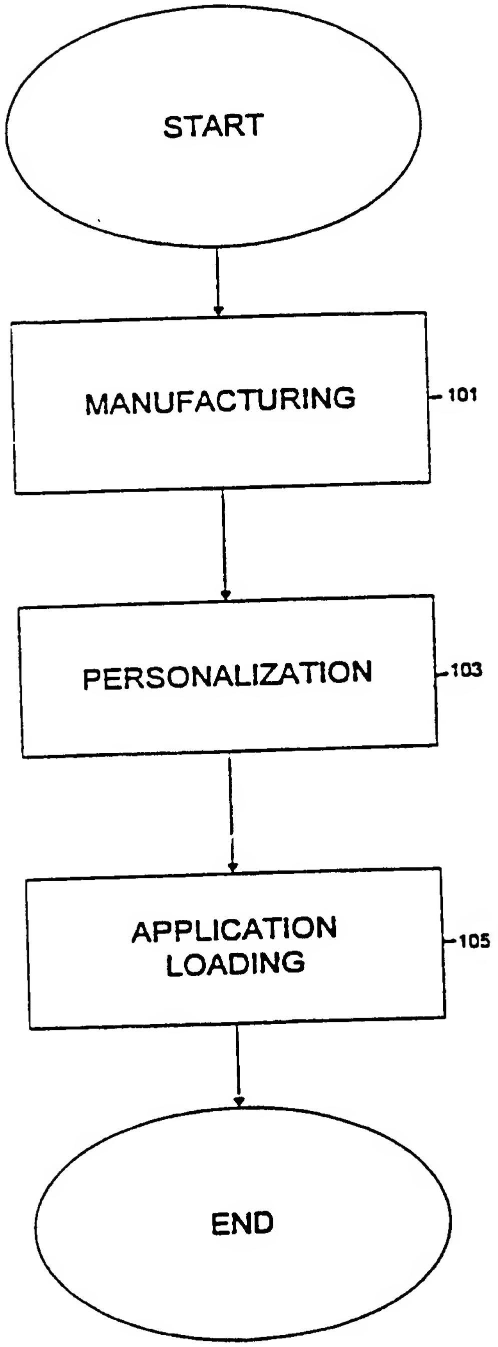

FIG. 1

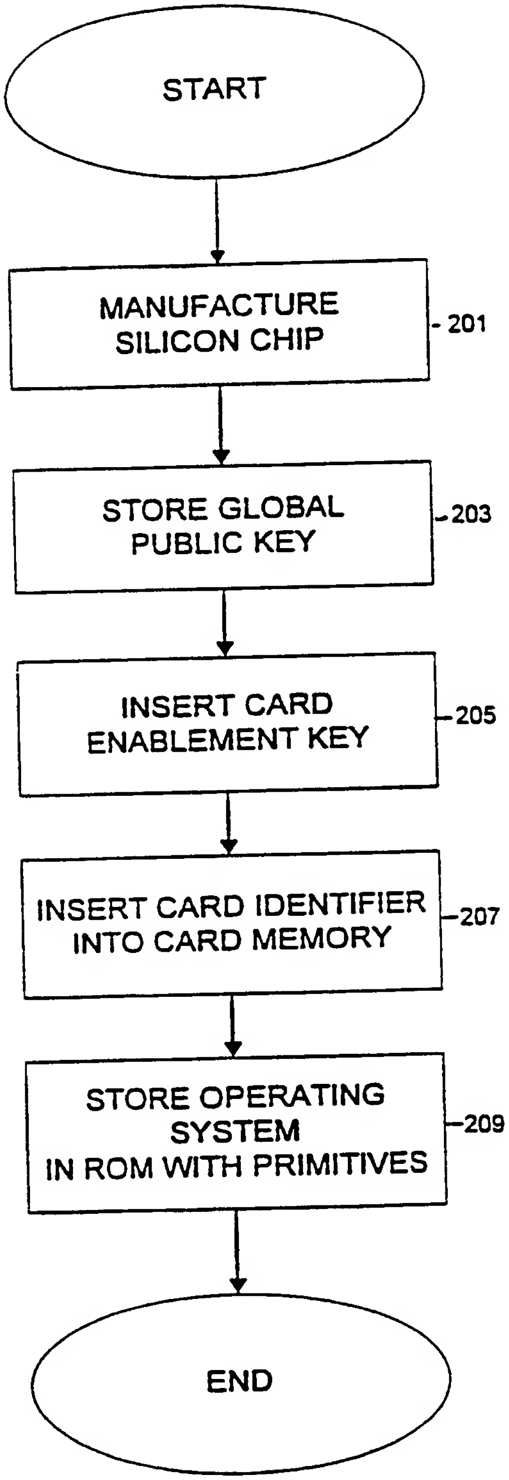
START
MANUFACTURE SILICON CHIP
201
STORE GLOBAL PUBLIC KEY
203
INSERT CARD ENABLEMENT KEY
205
INSERT CARD IDENTIFIER INTO CARD MEMORY
207
STORE OPERATING SYSTEM IN ROM WITH PRIMITIVES
209
END

FIG. 2

ANNEX A TO THE DRAWINGS

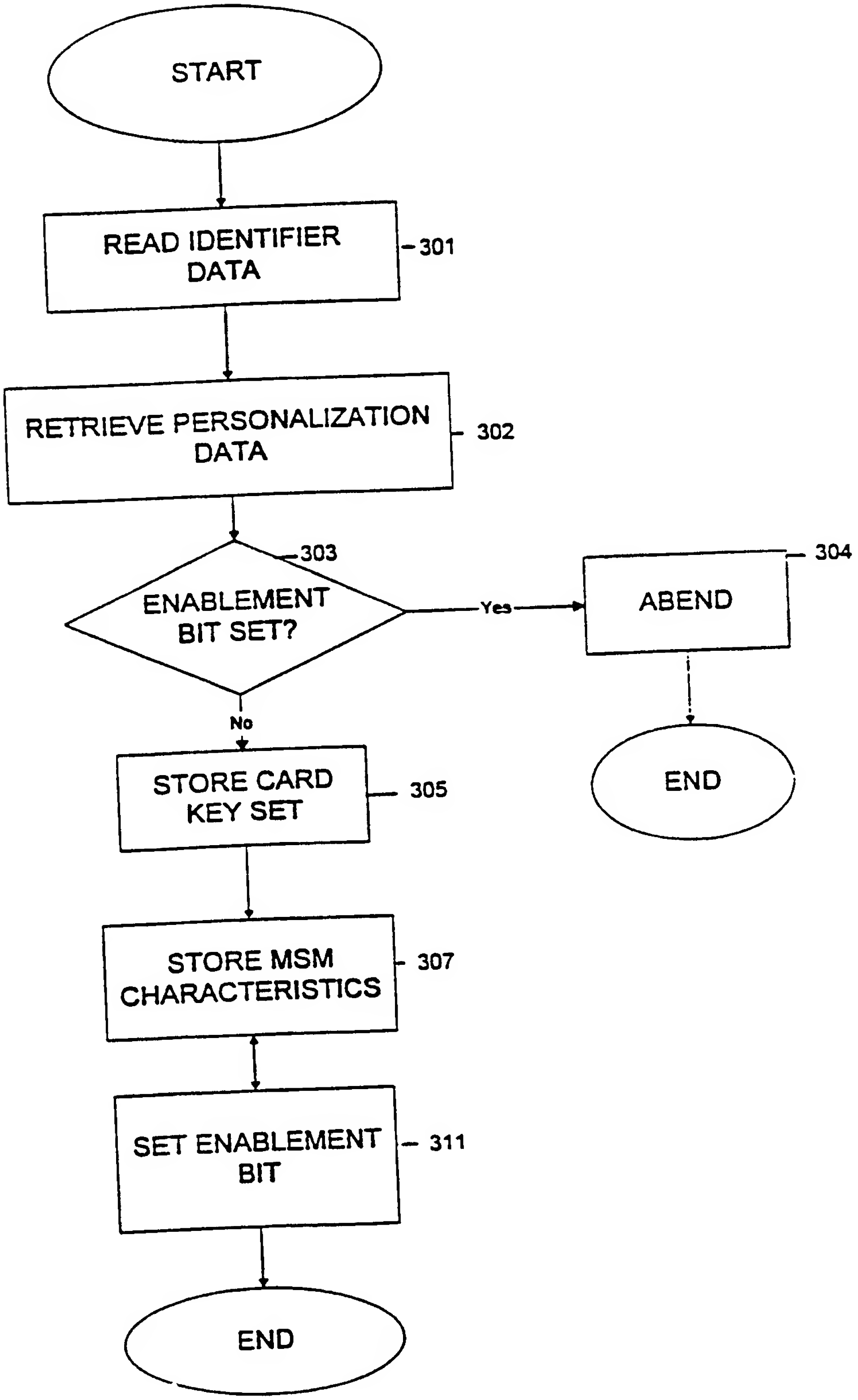

FIG. 3

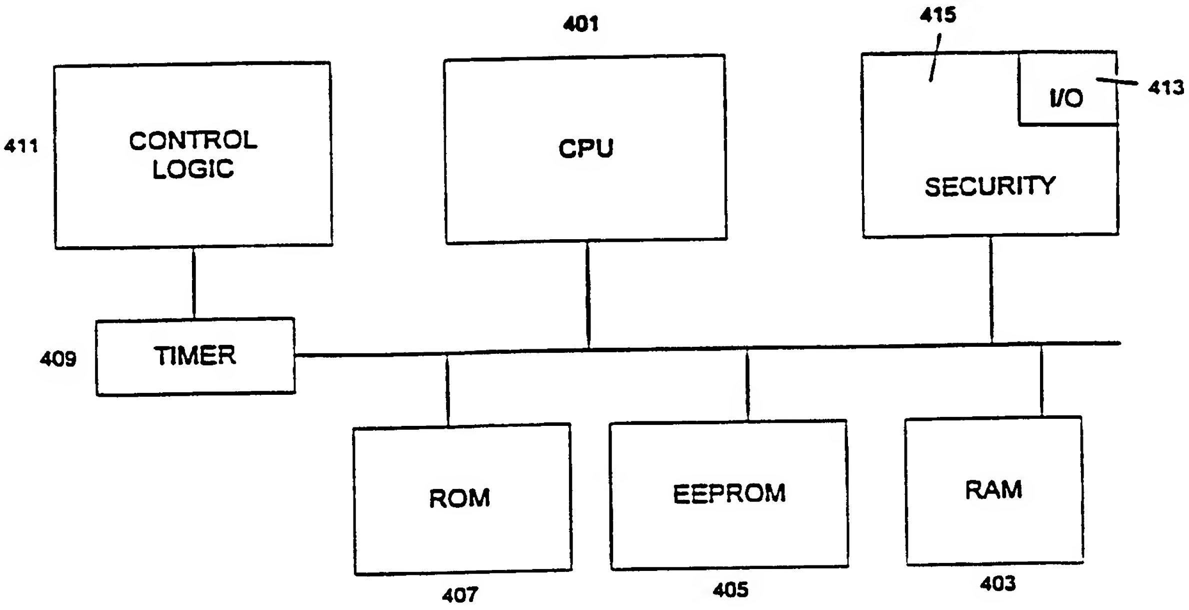
401
415
413
I/O
411
CONTROL LOGIC
CPU
SECURITY
409
TIMER
ROM
EEPROM
RAM
407
405
403

FIG. 4

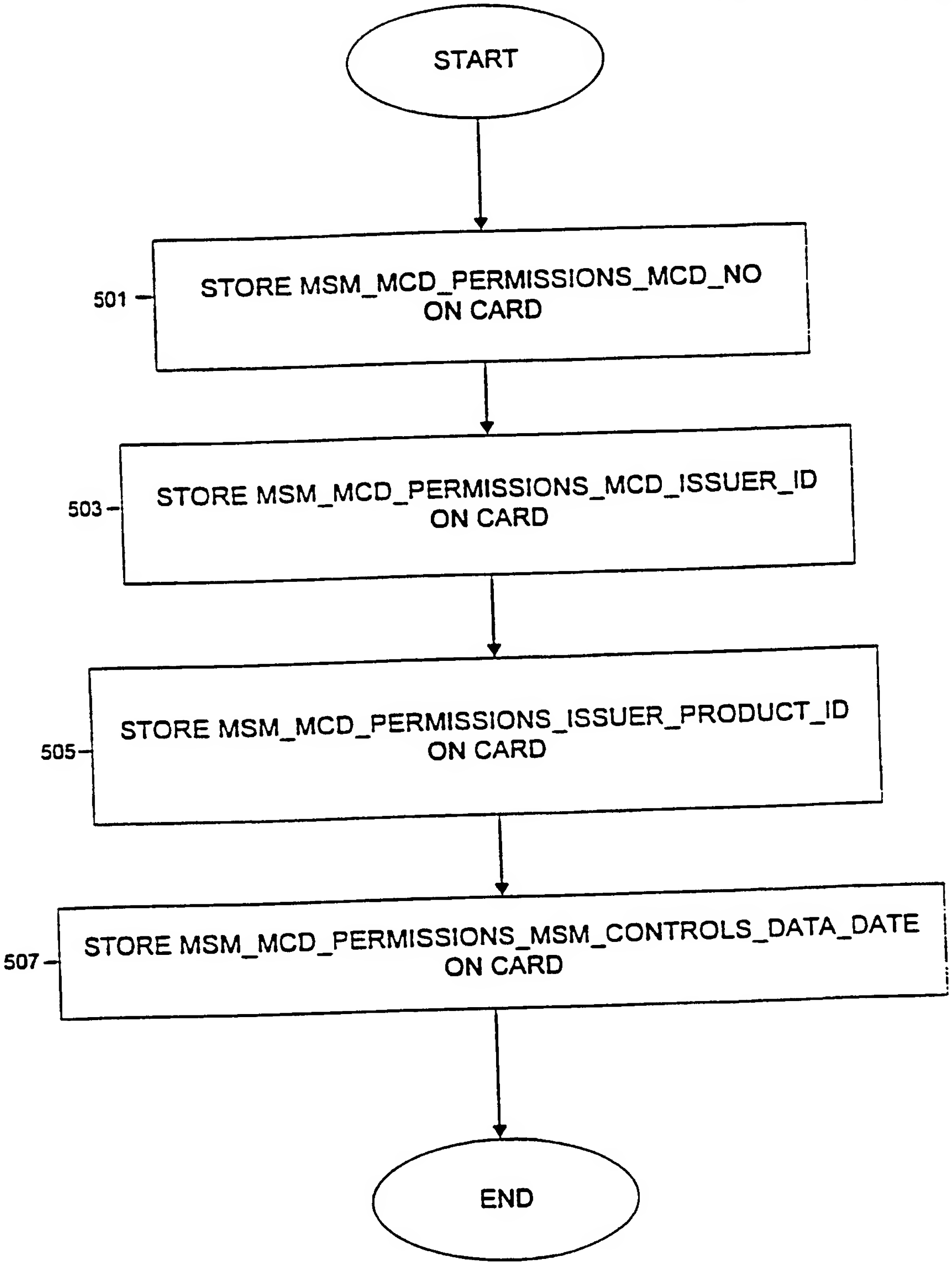
START
501
STORE MSM_MCD_PERMISSIONS_MCD_NO ON CARD
503
STORE MSM_MCD_PERMISSIONS_MCD_ISSUER_ID ON CARD
505
STORE MSM_MCD_PERMISSIONS_ISSUER_PRODUCT_ID ON CARD
507
STORE MSM_MCD_PERMISSIONS_MSM_CONTROLS_DATA_DATE ON CARD
END

FIG..5

ANNEX A TO THE DRAWINGS

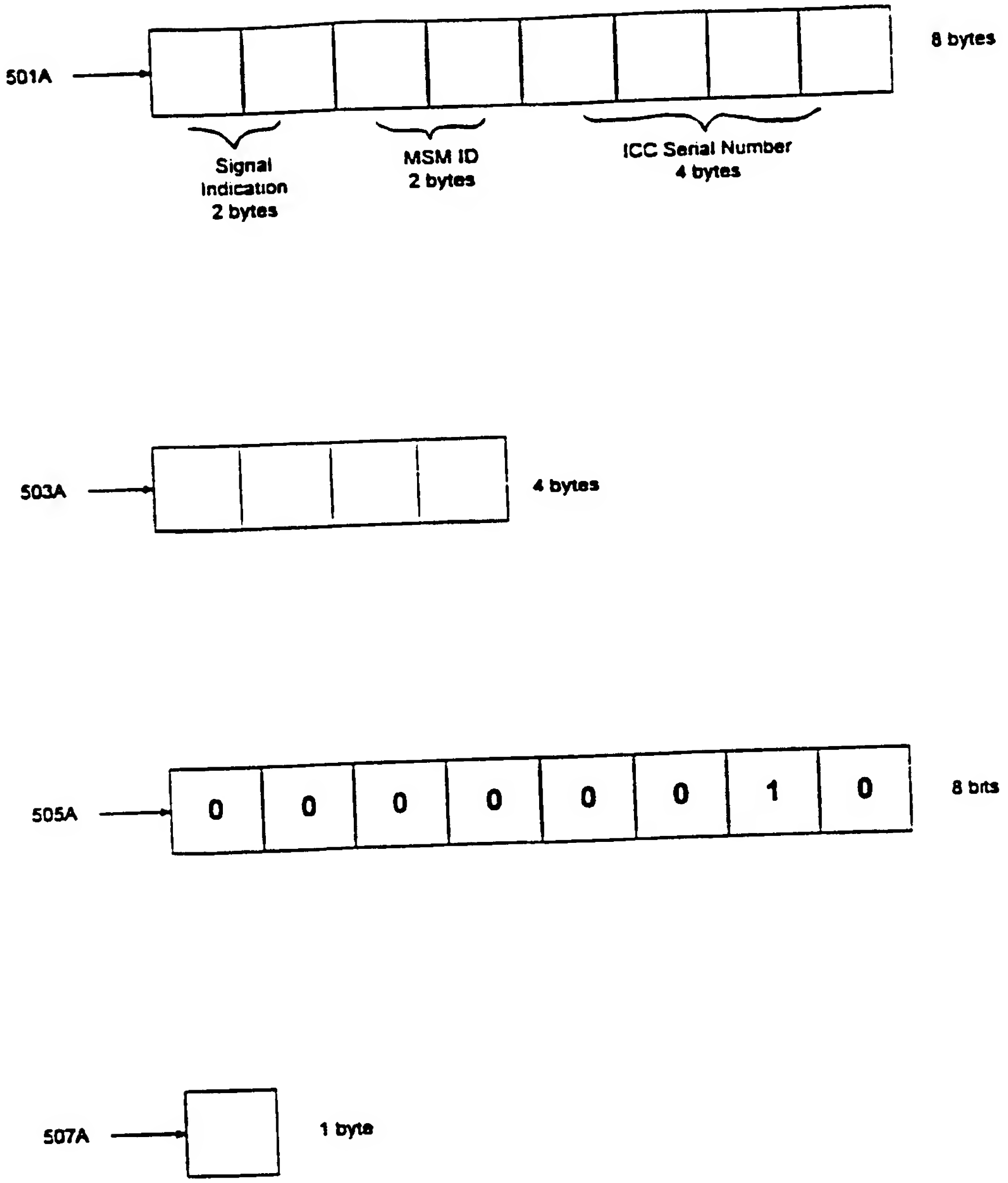

FIG. 5A

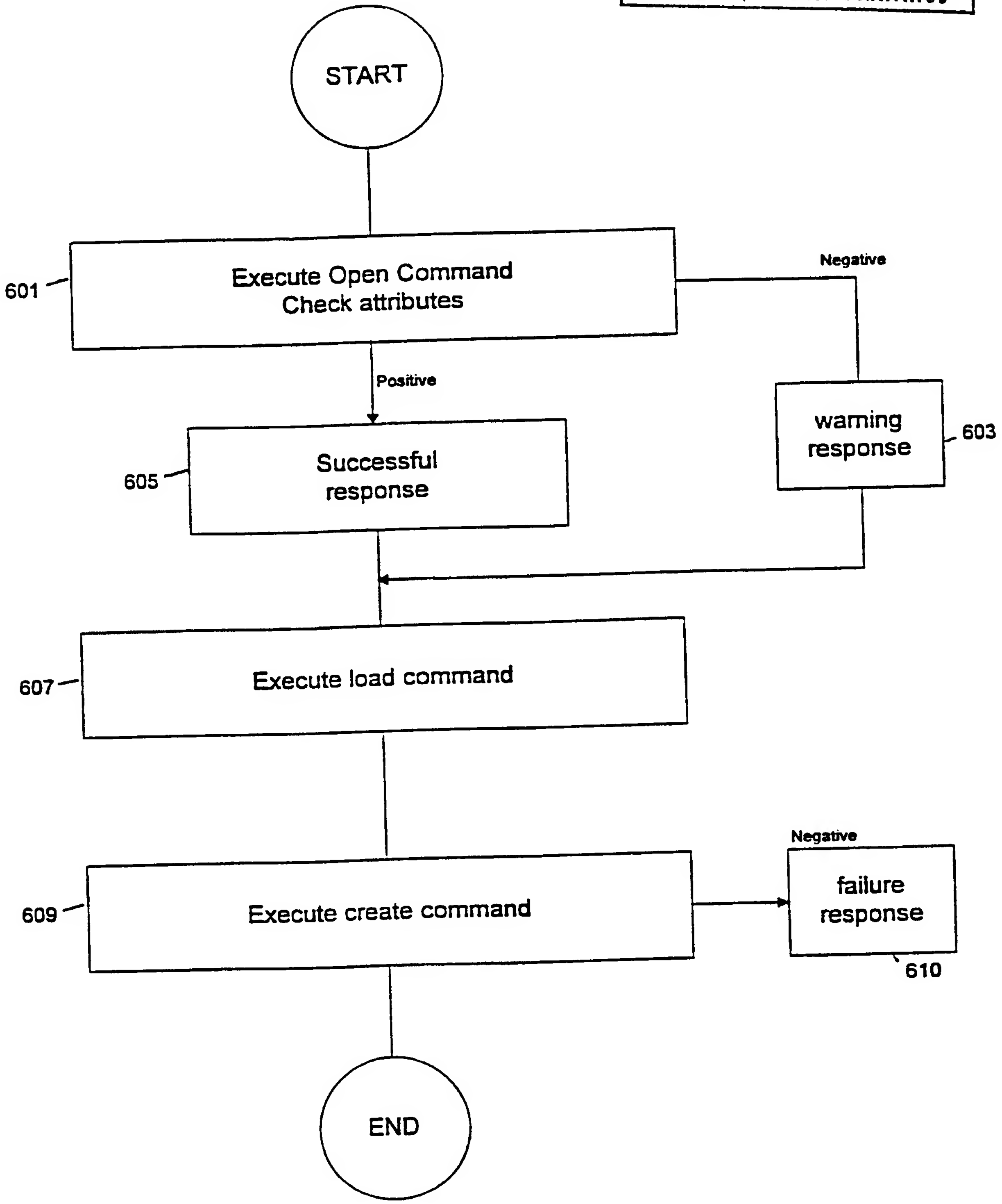
START
Execute Open Command
Check attributes
601
Negative
Positive
Successful
response
605
warning
response
603
Execute load command
607
Execute create command
609
Negative
failure
response
610
END

FIG. 6

ANNEX A TO THE DRAWINGS

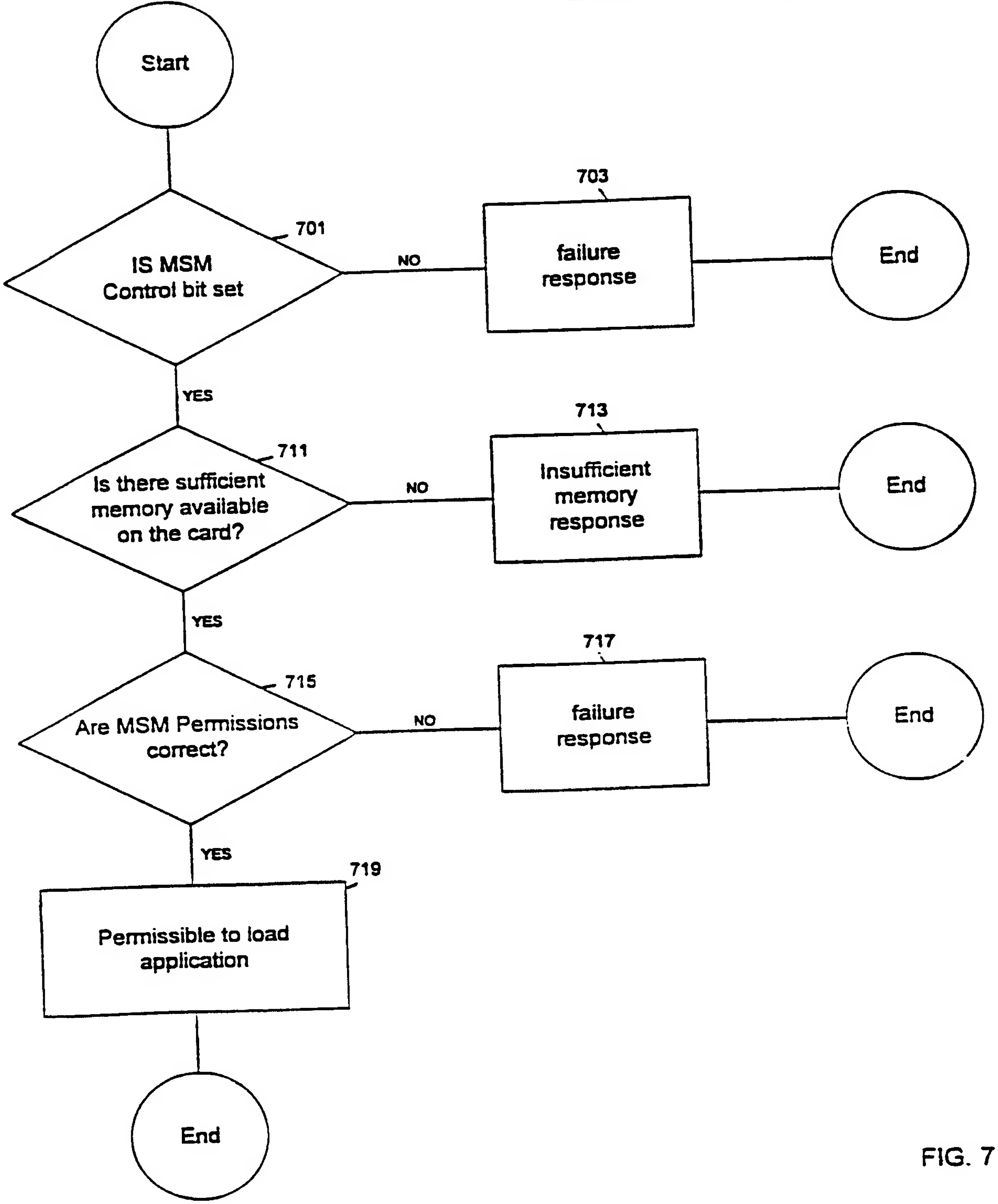
Start
701
IS MSM Control bit set
NO
703
failure response
End
YES
711
Is there sufficient memory available on the card?
NO
713
Insufficient memory response
End
YES
715
Are MSM Permissions correct?
NO
717
failure response
End
YES
719
Permissible to load application
End

FIG. 7

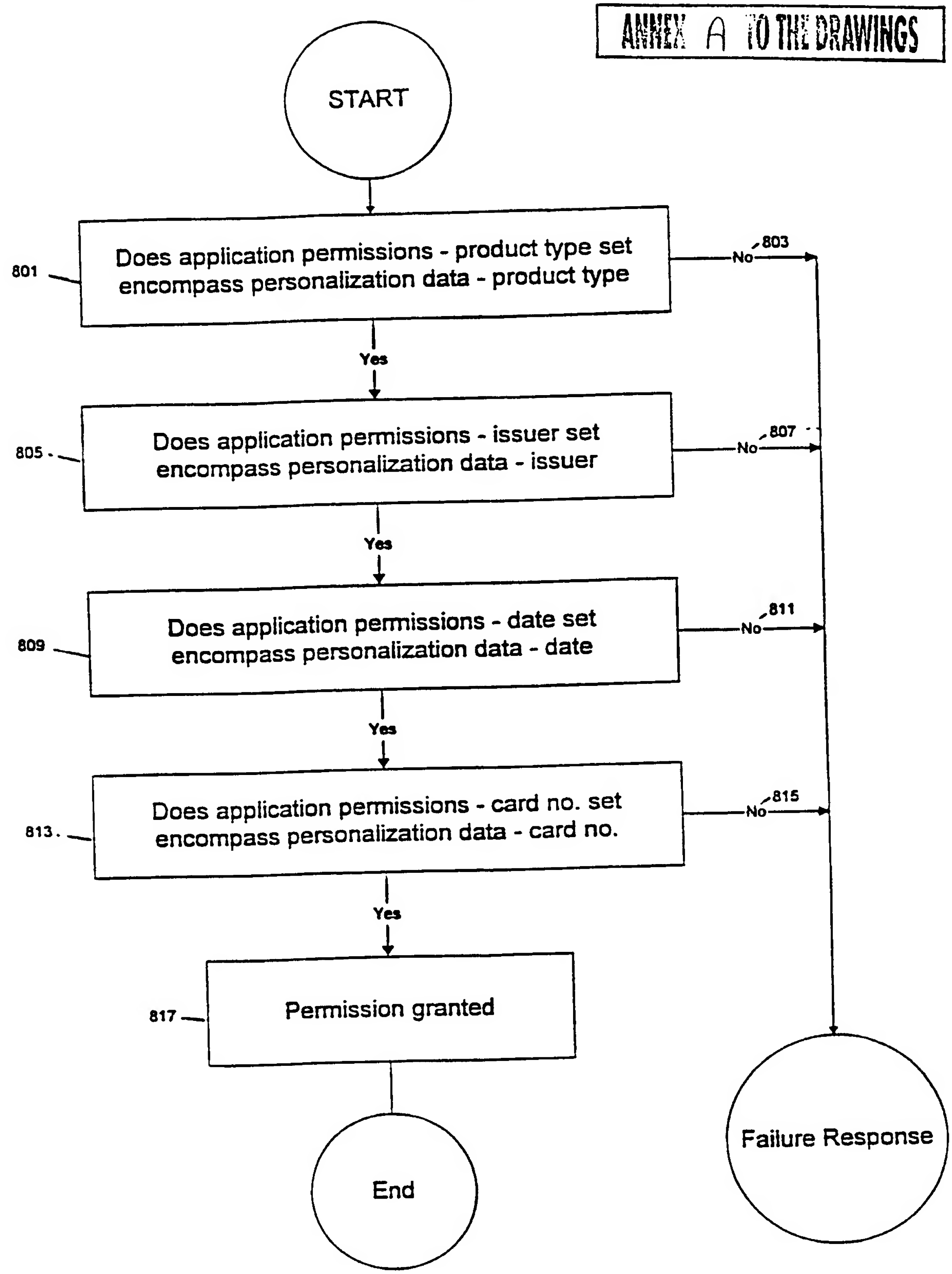
START
Does application permissions - product type set encompass personalization data - product type
801
No
803
Yes
Does application permissions - issuer set encompass personalization data - issuer
805
No
807
Yes
Does application permissions - date set encompass personalization data - date
809
No
811
Yes
Does application permissions - card no. set encompass personalization data - card no.
813
No
815
Yes
Permission granted
817
End
Failure Response

FIG. 8

ANNEX A TO THE DRAWINGS

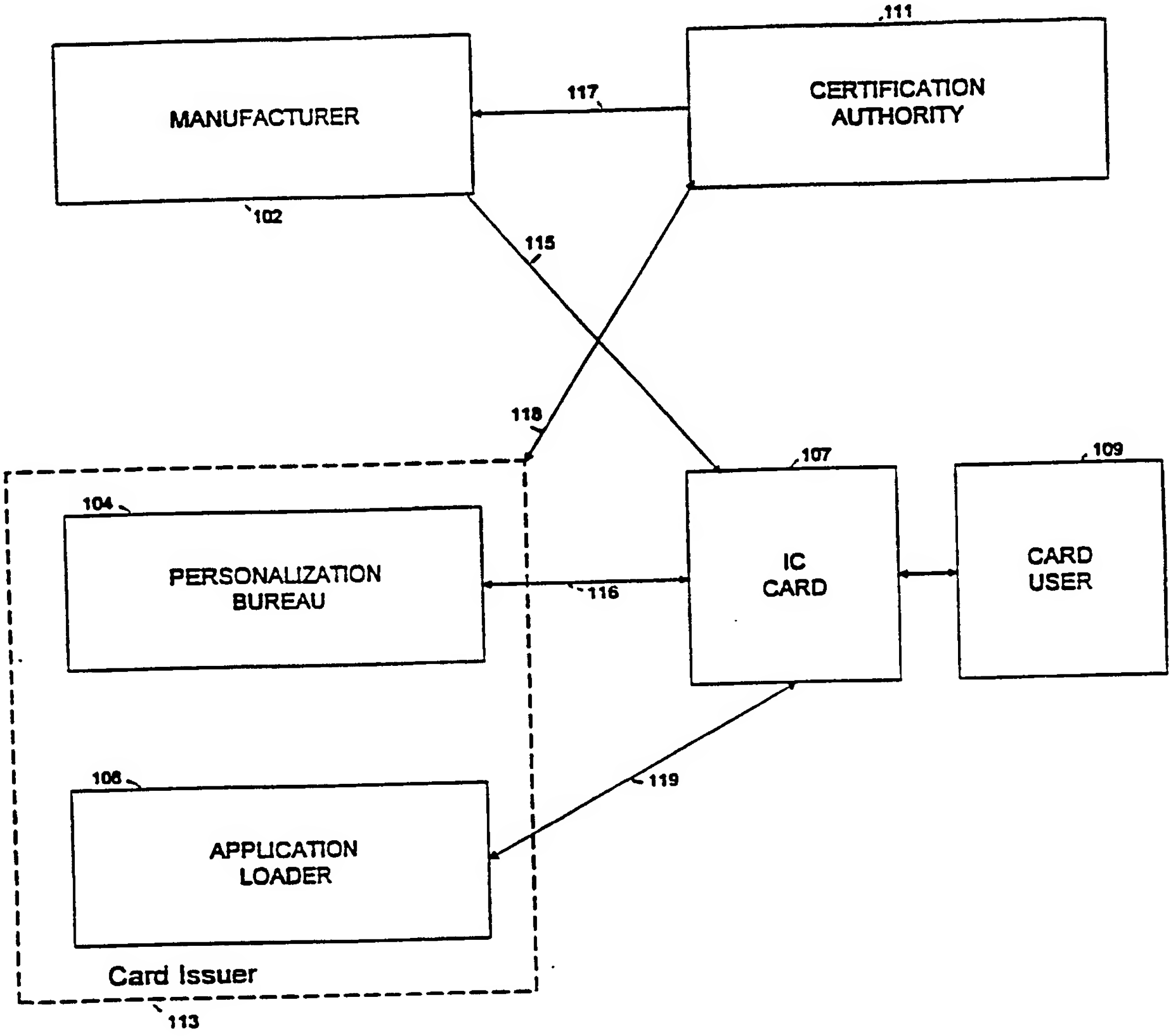

FIG. 9

ANNEX A TO THE DRAWINGS

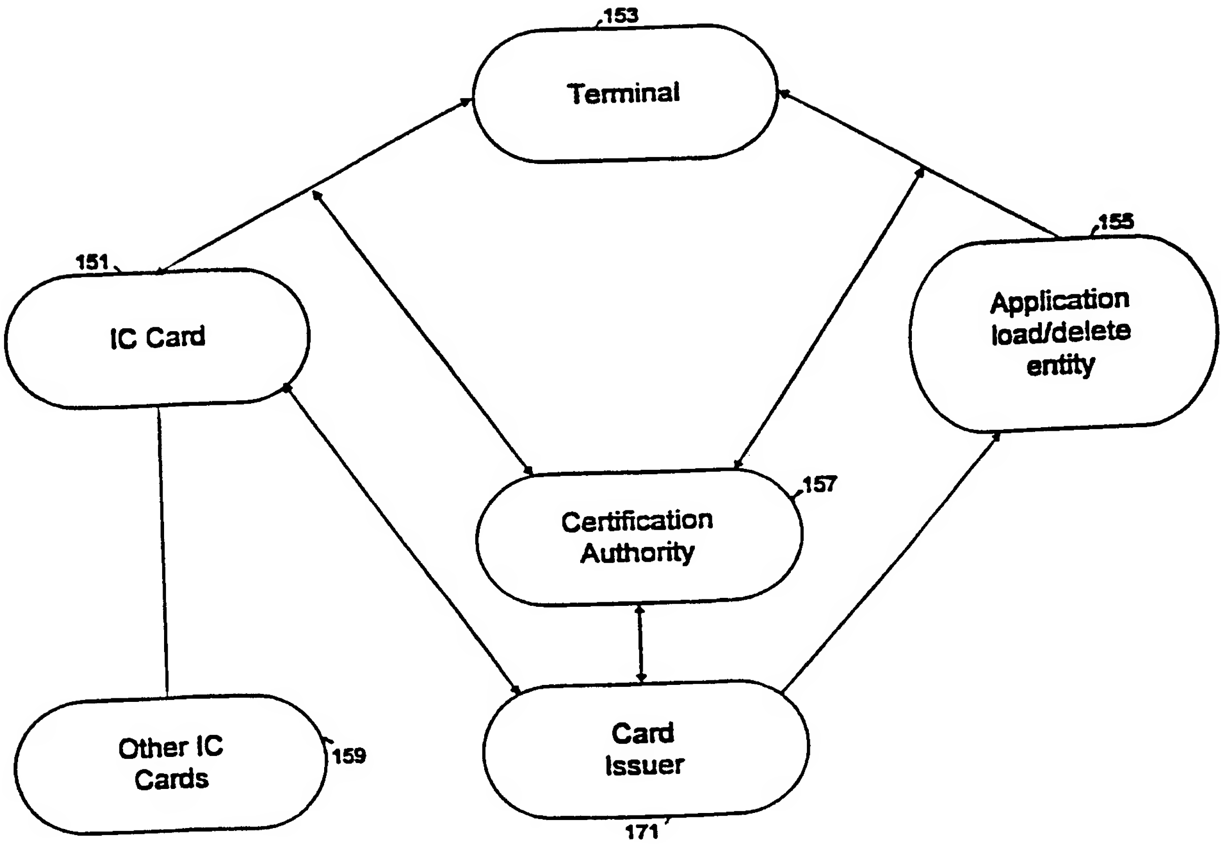

FIG. 10

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
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A3

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60/036,543	15 May 1997 (15.05.97)	US
09/023,057	12 February 1998 (12.02.98)	US
09/076,551	12 May 1998 (12.05.98)	US

(71) Applicant: MONDEX INTERNATIONAL LIMITED [GB/GB]; 47–53 Cannon Street, London EC4M 5SQ (GB).

(72) Inventors: EVERETT, David, Barrington; 31 Ashdown Avenue, Saltdean, Brighton, East Sussex BN2 8AH (GB). MILLER, Stuart, James; 9 Woodford Green, The Warren, Bracknell, Berks RG12 9YQ (GB). PEACHAM, Anthony, David; 4 Lynwood, Groombridge, Tunbridge Wells, Kent TN3 9LX (GB). SIMMONS, Ian, Stephens; The Elms, School Road, Broughton, Cambs PE17 3AT (GB). RICHARDS, Timothy, Philip; 32 Craig Mount, Radlett, Herts WD7 7LW (GB). VINER, John, Charles; Hydes, Woodlands Lane, Windlesham (GB).

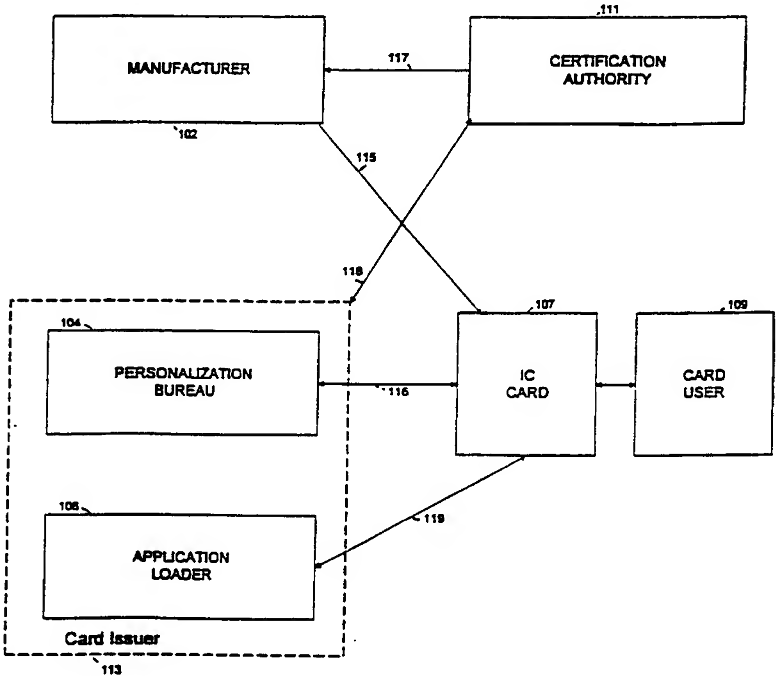
(74) Agent: POTTER, Julian, Mark; D. Young & Co., 21 New Fetter Lane, London EC4A 1DA (GB).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(88) Date of publication of the international search report: 3 June 1999 (03.06.99)

(54) Title: SECURE MULTIPLE APPLICATION CARD SYSTEM AND PROCESS



(57) Abstract

A secure multiple application card system and process are provided having secure loading and deleting capability by use of a Certification Authority and Personalization Bureau. The certification authority maintains the security of the system by requiring IC cards to be injected with its public key and a card identifier for uniquely identifying each card, by providing a personalization data block for each card, and by signing with its private key all applications to be loaded or deleted from the IC card.

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MC	Monaco
MD	Republic of Moldova
MG	Madagascar
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ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

INTERNATIONAL SEARCH REPORT

In. .ational Application No
PCT/GB 98/01402

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G07F7/10 H04L9/08 H04L9/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G07F H04L G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 292 248 A (THE GENERAL ELECTRIC COMPANY) 23 November 1988 see abstract; claims; figures see column 3, line 4 - line 44 ---	1,3,4,8, 9
A	WO 95 22810 A (TELIA) 24 August 1995 see abstract; claims; figures 1-3 see page 37 - page 38 ---	1,2,8-10
A	EP 0 325 506 A (SGS-THOMSON MICROELECTRONICS) 26 July 1989 see abstract; claims; figures ---	1-9
A	EP 0 475 837 A (GEMPLUS CARD INTERNATIONAL) 18 March 1992 ---	
A	EP 0 547 741 A (INTERNATIONAL COMPUTERS) 23 June 1993 --- -/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search 16 April 1999	Date of mailing of the international search report 23/04/1999
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer David, J

1

INTERNATIONAL SEARCH REPORT

In ational Application No
PCT/GB 98/01402

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 91 01538 A (CASH CARD SYSTEMS) 7 February 1991 -----	

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

In. .ational Application No
PCT/GB 98/01402

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0292248 A	23-11-1988	GB 2204973 A	23-11-1988
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		JP 1064033 A	09-03-1989
WO 9522810 A	24-08-1995	SE 502424 C	16-10-1995
		EP 0745247 A	04-12-1996
		SE 9400534 A	18-08-1995
EP 0325506 A	26-07-1989	FR 2626095 A	21-07-1989
		JP 2005160 A	10-01-1990
		JP 2759102 B	28-05-1998
		US 5014312 A	07-05-1991
EP 0475837 A	18-03-1992	FR 2666671 A	13-03-1992
		CA 2051365 A,C	13-03-1992
		DE 69100256 T	17-02-1994
		JP 4257031 A	11-09-1992
		JP 7056629 B	14-06-1995
		US 5191608 A	02-03-1993
EP 0547741 A	23-06-1993	US 5283830 A	01-02-1994
WO 9101538 A	07-02-1991	AU 5964290 A	22-02-1991